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THE DEVELOPMENT OF THE AMERICAN SOCIETY OF ANIMAL PRODUCTION [1]

H. M. BRIGGS

University of Wyoming

Organization

LIKE many organizations, the American Society of Animal Production had a very unpretentious beginning. During a summer school session at Cornell University in 1908 a group of persons interested in animal nutrition investigations held an informal conference on July 28 and fully discussed the need for an organization, the membership of which would sponsor nutritional research. At the original meeting, thirteen experiment stations and the Office of Experiment Stations of the United States Department of Agriculture were represented.

Before the meeting adjourned a committee was appointed and instructed "to consider the desirability of forming a permanent organization of animal nutrition investigators and, in case it is deemed wise to do so, this committee be given power to call a meeting of animal nutrition investigators at some future time and present plans for permanent organization; that the committee be instructed to make a survey of the field of animal husbandry work and present suggestions for plans of cooperation among various experiment stations." [2] This committee which consisted of H. P. Armsby of Pennsylvania, W. H. Jordan of New York, H. J. Waters of Missouri, H. R. Smith of Nebraska, and J. H. Skinner of Indiana, completed their assignment and called a meeting in Chicago at the time of the International Livestock Exposition in a room of the Livestock Records Building [3] on November 28, 1908. The committee rendered its report and it was voted to organize as The American Society of Animal Nutrition. The outlined plan of the committee was adopted, after amendment, as the constitution of the Society with the objectives "to improve the quality of investigation in animal nutrition, to promote more systematic and better correlated

[1] Prepared and published at the request of the Executive Committee of the American Society of Animal Production.

[2] The American Society of Animal Nutrition Organization Meeting, 1908. Publlshed by the Society, June, 1909.

[3] Letter from Dr. E. B. Forbes, a charter member of the Society.

study of feeding problems and to facilitate personal intercourse between investigators in this field." [4] The charter members of the Society were: [5]

Allison, H. O., Illinois Agricultural Experiment Station
Armsby, H. P., Pennsylvania State College Institute of Animal Nutrition
Boss, Andrew, Minnesota Agricultural Experiment Station
Burgess, J. M., South Carolina Agricultural Experiment Station
Burns, J. C., Texas Agricultural Experiment Station
Cochel, W. A., Indiana Agricultural Experiment Station
Curtiss, C. F., Iowa Agricultural Experiment Station
Dietrich, William, Illinois Agricultural Experiment Station
Forbes, E. B., Ohio Agricultural Experiment Station
Gaumnitz, D. A., Minnesota Agricultural Experiment Station
Gray, D. T., Alabama Agricultural Experiment Station
Grout, G. P., Minnesota Agricultural Experiment Station
Haecker, T. L., Minnesota Agricultural Experiment Station
Hall, L. D., Illinois Agricultural Experiment Station
Hayward, H., Delaware Agricultural Experiment Station
Jaffa, M. E., California Agricultural Experiment Station
Kennedy, W. J., Iowa Agricultural Experiment Station
Kinzer, R. J., Kansas Agricultural Experiment Station
Lehman, A., Ohio Agricultural Experiment Station
Mumford, F. B., Missouri Agricultural Experiment Station
Mumford, H. W., Illinois Agricultural Experiment Station
Otis, D. H., Wisconsin Agricultural Experiment Station
Riley, E. H., United States Department of Agriculture, Bureau of Animal Industry
Shaw, E. L., United States Department of Agriculture, Bureau of Animal Industry
Shaw, R. S., Michigan Agricultural Experiment Station
Skinner, J. H., Indiana Agricultural Experiment Station
Smith, H. R., Nebraska Agricultural Experiment Station
Smith, P. H., Massachusetts Agricultural Experiment Station
Trowbridge, E. A., Missouri Agricultural Experiment Station
Wade, R. W., Ontario Agricultural Experiment Station (Canada)
Waters, H. J., Missouri Agricultural Experiment Station
Webster, E. H., United States Department of Agriculture, Bureau of Animal Industry
Willard, J. T., Kansas Agricultural Experiment Station

Development of the Society

The next business session and the first meeting of the Society at which papers were presented was held in the Exposition Hall at Chicago on November 27 and 29, 1909. By that time there were 100 members listed on the roster although only 78 had paid the annual dues of one dollar. At that meeting it was voted that dues should be two dollars and that an annual proceedings should be published. A

[4] The American Society of Animal Nutrition Organization Meeting, 1908. Published by the Society, June, 1909.

[5] The original published list contained the names of only 32 members but Dr. H. P. Armsby, the first president, later noted the name of C. F. Curtiss, the first person to be elected to the office of vice-president, had been omitted.

Standing Committee on Experiments was appointed and, although the word Investigations was later used to replace that of Experiments, that Committee has always remained an important one in the Society. In fact, in the infancy of the Society it was that Committee which probably kept it alive. The 1910 meeting was held in the Congress Hotel in Chicago on November 27. The following year the group met on November 13 at Columbus, Ohio, and then held an adjourned meeting at Chicago on December 5.

The next two years proved to be eventful and crucial ones for the Society. As a society limited to nutritional research, the organization did not seem to flourish, although two papers were direct outgrowths of the effort.[6] At the 1912 meeting held on November 30 in the Pure Bred Livestock Record Building, it was voted to change the name to The American Society of Animal Production and to broaden the scope of the Society; the constitution was amended to include breeding and management investigations as interests of the Society, and made instructional persons eligible for membership. Even with the broadened scope, the Society almost failed. The constitution was revised in 1915 and remained the operating guide of the organization with only minor amendments until a revision was made in 1932. In 1942, the constitution underwent a major revision (JOURNAL OF ANIMAL SCIENCE 1:95–99, 1943) and has remained the operating constitution to date, with but minor revisions.

The Society president, C. F. Curtiss, insisted that the 1913 meeting should be only a "social" one, but a "protest" meeting was called by the vice-president, E. B. Forbes, in a room over the sheep barn in the stockyards and papers on feeding problems were presented by E. B. Forbes, John M. Evvard, F. G. King, and W. A. Cochel. A Committee on Instruction was appointed and has continued to function as a standing committee of the Society. Living charter and early members generally give credit to Dr. H. P. Armsby for giving the Society much of its early impetus, but give Dr. E. B. Forbes credit for becoming the "savior" of the Society by his refusal to succumb to executive pressure. There has been general growth in size and influence since that time.

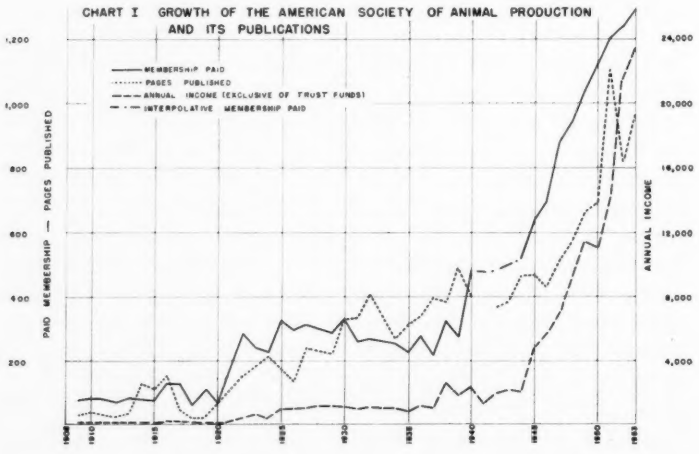
It was not until 1920 that the time and meeting place of the Society became established. In 1914 the meeting was held in Washington, D. C.; 1915 at Kansas State College, Manhattan, Kansas; 1916 at the University of Illinois, Urbana, Illinois; 1917 at Iowa State College, Ames, Iowa; 1918 at the University of Wisconsin, Madison, Wisconsin; and

[6] Bulletin of the National Research Council, Vol. 2, Part 4, No. 12, June, 1921 and Bulletin of the National Research Council, Vol. 7, Part 6, No. 42, February, 1924.

1919 at Purdue University, Lafayette, Indiana. The 1920 meeting was held at the LaSalle Hotel in Chicago the Friday and Saturday following Thanksgiving and immediately preceding the International Livestock Exposition; these meeting dates have been retained since that time. The following year the Sherman Hotel was chosen as the meeting site and has remained such except for the 1944 meeting which was held in the Morrison Hotel.

The Society dues remained $2 until 1926 when the rate was raised to $3 by vote of the membership at the annual meeting. The 1932 constitution gave the Executive Committee the power to recommend dues to the membership for their approval at the annual meeting and the 1942 constitution gave the Executive Committee the responsibility of establishing the dues. In the interim decade, dues were changed slightly from time to time but varied from $2.50 to $3.00. The dues were placed at $3 in 1942, $3.50 in 1945, $4 in 1949, and were raised to $5 in 1952. A registration fee of 50¢ per registrant was established in 1943. The fee remained at this rate until 1952 when it was raised to $1.

The membership list for many years was not an accurate index of the active or dues paying membership. Chart I indicates the number of persons who actually paid dues, the annual income exclusive of grants, and the total number of pages published by the Society either as Proceedings or as the JOURNAL OF ANIMAL SCIENCE.



Society Publications

An annual proceedings was published either currently or eventually for each meeting through the 1940 sessions and the secretary served as editor. At that time an Editorial Committee recommended the establishment of a journal and the action was approved by the Society. This action was a final culmination of much consideration and effort on the part of several committees and individuals who for more than a decade had intermittently studied the problems of journal publication. An editorial board was appointed and the first volume of the Journal, a quarterly, was published in 1942. Dr. Ralph W. Phillips was appointed as the editor of the JOURNAL OF ANIMAL SCIENCE and served faithfully until he was succeeded in 1949 by Dr. L. E. Casida, the present editor; Dr. J. K. Loosli was appointed associate editor in 1951 and Dr. W. D. Gallup was selected as Assistant Editor in 1953. The JOURNAL OF ANIMAL SCIENCE was published by the Geo. Banta Publishing Company of Menasha, Wisconsin, from its inception through 1950 when that activity was taken over by the Boyd Publishing Company of Albany, New York.

The first number of the Journal carried abstracts of papers presented at the 1941 meeting of the Society and the report of that meeting. Since that time abstracts presented for consideration of the program committees are published in the November, or No. 4, issue preceding the meetings. The report of the preceding annual meeting is carried in the February, or No. 1, issue of each volume. The presentation of a paper at the annual meetings does not necessarily carry publication privileges but publication of papers is at the discretion of the editorial board.

There were 177 subscribers to the Journal in 1942, in addition to those that secured numbers of the Journal by reason of their membership in the Society. There has been a continual growth in the subscription list and by 1953 there were 1,000 subscriptions. This is certainly indicative of the favor the JOURNAL OF ANIMAL SCIENCE has found as a scientific organ.

Annual Meetings

Until the 1923 meeting the meetings were general sessions but for the next several years subject matter sections were held in addition to a general and business session. These subject matter sessions were largely divided by classes of livestock or other general criteria until 1945 when the division was changed to place more emphasis on the

type of work being reported than on the class of animals used as experimental subjects. The business meeting of the Society has customarily followed a luncheon held the second day of the annual meeting. Symposia have occasionally been held during the meeting on current problems of unusual interest. The opening session has usually been given over to a general program.

Since 1921 one of the important functions of the Society and the highlight of nearly every annual meeting has been the presentation of the portrait of an honor guest to the Saddle and Sirloin Club for inclusion in their famous gallery of those who have made very noteworthy contributions to the development of the livestock industry. Usually a banquet honoring the member has been held on Sunday evening in the Saddle and Sirloin Club banquet room as the final session of the Society. Members of the Society who have been so honored are:

1921	H. P. Armsby	1937	W. A. Cochel
	J. H. Sheppherd	1938	F. B. Morrison
1922	H. L. Russell	1939	Leon J. Cole
1923	C. S. Plumb	1940	E. S. Good
1924	Eugene Davenport	1941	E. A. Trowbridge
1925	C. F. Curtiss	1942	no honor guest
1926	John H. Mohler	1943	H. L. Garrigus
1927	Gordon H. True	1944	F. G. King
1928	F. B. Mumford	1945	no meeting held
	H. W. Mumford	1946	Henry P. Rush
1929	Andrew Boss	1947	G. H. Hart
1930	E. A. Barnett	1948	W. H. Peters
1931	W. L. Carlyle	1949	J. A. Hill
1932	no honor guest	1950	C. W. Gay
1933	Robert S. Shaw	1951	G. Bohstedt
1934	E. B. Forbes	1952	A. D. Weber
1935	G. C. Humphrey	1953	P. S. Shearer
1936	W. C. Coffey		

There are three sectional societies that function under the auspices of the American Society of Animal Production. The western section was organized at its first annual meeting held at Miles City, Montana, on August 20–24, 1928. That same year a meeting of the southern section was reported. In 1932 the first formal meeting of the north Atlantic section was held. The sectional meetings are usually held at different places in their respective regions each year, often at institutions or in conjunction with other events. The officers are elected by the regional membership and there are usually dues or assessments made on members.

The Executive Committee of the Society has always had the elected officers of the Society as its members. The 1942 constitution established

an Executive Committee consisting of the elected officers, the regional vice-president, the editor of the Journal, and the outgoing president. The elected officers have been as follows:

	President	Vice-President	Secretary-Treasurer
1908	H. P. Armsby	C. F. Curtiss	D. H. Otis
1909	H. P. Armsby	C. F. Curtiss	D. H. Otis
1910	H. P. Armsby	C. F. Curtiss	D. H. Otis
1911	H. P. Armsby	C. F. Curtiss	D. H. Otis
1912	H. J. Waters	C. F. Curtiss	D. H. Otis
1913	C. F. Curtiss	E. B. Forbes	D. H. Otis
1914	E. B. Forbes	J. H. Skinner	D. H. Otis
1915	E. B. Forbes	W. H. Cochel	F. B. Morrison
1916	W. A. Cochel	J. M. Evvard	F. B. Morrison
1917	H. S. Grindley	J. M. Evvard	F. B. Morrison
1918	J. M. Evvard	E. A. Trowbridge	E. S. Savage
1919	F. B. Morrison	H. W. Mumford	E. S. Savage
1920	F. B. Morrison	H. W. Mumford	E. S. Savage
1921	W. C. Coffey	E. S. Savage	G. Bohstedt
1922	W. C. Coffey	F. G. King	G. Bohstedt
1923	F. G. King	G. Bohstedt	E. W. Sheets
1924	E. A. Trowbridge	G. Bohstedt	E. W. Sheets
1925	G. Bohstedt	H. P. Rusk	E. W. Sheets
1926	H. P. Rusk	E. S. Good	E. W. Sheets
1927	E. S. Good	E. W. Sheets	James R. Wiley
1928	E. W. Sheets	H. J. Gramlich	James R. Wiley
1929	H. J. Gramlich	James R. Wiley	W. E. Carroll
1930	James R. Wiley	C. W. McCampbell	W. E. Carroll
1931	C. W. McCampbell	George C. Humphrey	W. E. Carroll
1932	J. A. Hill	W. E. Carroll	William J. Loeffel
1933	George C. Humphrey	W. E. Carroll	William J. Loeffel
1934	W. E. Carroll	H. H. Kildee	William J. Loeffel
1935	H. H. Kildee	William J. Loeffel	J. L. Lush
1936	William J. Loeffel	G. A. Brown	J. L. Lush
1937	G. A. Brown	D. W. Williams	J. L. Lush
1938	D. W. Williams	J. L. Lush	R. M. Bethke
1939	J. L. Lush	G. H. Hart	R. M. Bethke
1940	G. H. Hart	W. H. Peters	R. M. Bethke
1941	W. H. Peters	R. M. Bethke	A. D. Weber
1942	R. M. Bethke	L. A. Maynard	A. D. Weber
1943	L. A. Maynard	L. A. Weaver	A. D. Weber
1944	L. A. Weaver	A. D. Weber	W. V. Lambert
1945	A. D. Weber	W. A. Craft	W. V. Lambert and W. G. Kammlade
1946	A. D. Weber	W. A. Craft	W. G. Kammlade
1947	W. A. Craft	Paul Gerlaugh	W. G. Kammlade
1948	Paul Gerlaugh	W. G. Kammlade	H. M. Briggs
1949	W. G. Kammlade	P. S. Shearer	H. M. Briggs
1950	P. S. Shearer	E. W. Crampton	H. M. Briggs
1951	E. W. Crampton	H. M. Briggs	J. I. Miller
1952	H. M. Briggs	M. L. Baker	J. I. Miller
1953	M. L. Baker	A. E. Darlow	J. I. Miller
1954	A. E. Darlow	J. I. Miller	W. M. Beeson

In 1946 Frank B. and Elsie Morrison made a cash grant of $5,000 to the Society to be used in making annual awards to members who had made outstanding contributions to the industry through livestock research. Additional deposits were made to the fund and by 1948 a total of $35,000 had accumulated and an irrevocable trust was established to be used by the Society as long as it exists and pass to its successor if the Society should be discontinued. The annual award was a $1000 cash award until increased to $1250 in 1953, an appropriate certificate, and an engraved remembrance for the recipient. Members who have received the Morrison Award are:

1946	J. L. Lush
1947	W. L. Robison
1948	L. M. Winters
1949	G. Bohstedt
1950	H. W. Mitchell
1951	A. G. Hogan
1952	H. H. Cole
1953	Max Kleiber

In 1948 the American Feed Manufacturers Association established an annual award of $1000 to be made to the member of the Society whose published papers had indicated the greatest contribution to animal nutrition during the preceding two years. Recipients of this award have been:

1948	E. W. Crampton
1949	J. L. Krider
1950	J. K. Loosli
1951	L. E. Harris
1952	W. M. Beeson
1953	D. V. Catron

Affiliations

The American Society of Animal Production has associated itself from time to time with other organizations with which it has mutual interests. These affiliations have consisted of having a member appointed to serve as liaison. Organizations with which the Society keeps such affiliations are the Inter-Society Association Council, the American Association for the Advancement of Science, the European Animal Husbandry Association, the Division of Biology and Agriculture of the National Research Council, and the Agricultural Research Institute.

The American Society of Animal Production has never been a dues paying member of another organization.

Unsolved Problems

Many problems have confronted the Society since its organization and most of these have been faced and solved courageously. However, within recent years the Executive Committee and membership have been studying problems which have been facing most organizations of a similar nature. Spiraling costs have presented budgetary problems. The Society has had a heavy publication cost and has always felt reluctant to sell advertising in its publications. To date the Society has prided itself in publishing one of the few scientific journals that does not carry paid advertisements. Increases in the number of papers published and in the number of members on the Society rolls have placed a heavy load on the offices of the editor and secretary-treasurer, and neither position carries financial remuneration; both offices have an allowance for secretarial assistance.

In recent years the Executive Committee has been encouraged to authorize the publication of monographs; how these might be financed has been debated. At present such a manuscript is being readied for publication and will be available to members at a nominal cost.

Perhaps the most pressing problem the Society has been facing and will continue to face is that of how to cope with the problem of the presentation of papers at annual meetings. As early as 1935 the Society authorized the secretary to limit the length of time on papers. In recent times program committees have been requested to select papers which would be actually presented before the sectional meetings. Physical limitations in suitable meeting rooms have not made additional sections seem feasible and many members have suggested too many papers are now being presented simultaneously. These problems are only the normal ones that any growing organization must face and attempt to solve.

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JOURNAL OF ANIMAL SCIENCE, Volumes I–XI, 1942–53.
History of Livestock in the United States, by Carl W. Gay, prepared for the American Society of Animal Production, 1951.
The Growth of Our Society, by James R. Wiley, the presidential address before

the Society in 1930, Annual Proceedings of the American Society of Animal Production, pp. 9–13, 1930.

President's Address, by P. S. Shearer, JOURNAL OF ANIMAL SCIENCE, 10:284–287, 1951.

Personal correspondence from charter and early members including:

G. Bohstedt
W. E. Carroll
W. A. Cochel
W. C. Coffey
E. B. Forbes
J. G. Fuller
C. W. Gay
M. P. Jarnigan
H. H. Kildee
C. D. Lowe
H. H. Mitchell
F. B. Morrison
O. E. Reed
W. W. Smith
E. N. Wentworth
J. R. Wiley

THE EFFECT OF RESTRICTING FEED INTAKE OF MARKET HOGS DURING THE FINISHING PERIOD ON THE QUALITY OF THE BACON CARCASS

E. W. Crampton, G. C. Ashton and L. E. Lloyd

Macdonald College [1]

THE problem of rate of gain in bacon pigs in relation to carcass excellence has been studied in England by McMeekan and Hammond (1939) and McMeekan (1940). These studies showed that growth during particular periods had a greater effect on carcass composition than average growth over the whole feeding period. For example, muscle formation in the bacon hog increases from birth up to sixteen weeks of age and then declines, while fat deposition increases progressively up to market weight. Using these figures as a basis for their practical work, the English workers reported that a rapid rate of growth up to 16 weeks, accomplished by full feeding, followed by a decelerated growth rate to market weight, accomplished by restricted feeding, produced the best type of bacon carcass. McMeekan also found that the proportion of top grade bacon carcasses was raised from 30 to 90% in actual practice among farmers by slowing down growth rate during the last five or six weeks of the feeding period by restricting feed intake. This increase in carcass quality was invariably associated with a decreased proportion of fat to lean.

The experience of over thirty years of marketing hogs on a bacon quality basis in Canada has demonstrated that the most common factor influencing grade is the proportion of fat to lean in the carcass. More carcasses have been penalized for overfinishing, i.e. a high ratio of fat to lean, than for any other reason. As a result, the efforts of the hog industry have been directed towards producing bacon carcasses with a low proportion of fat.

In 1944 a long term study of nutritional factors affecting bacon carcass characteristics was undertaken by this Department. This paper reports the results of one of the early tests in this series. The problem under study in this trial was whether or not McMeekan's scheme of restricting feed for the latter part of the feeding period would, under Canadian management and feeding conditions, result in a general increase in the proportion of Grade A bacon carcasses as scored under Canadian standards of excellence.

[1] Contribution from the Faculty of Agriculture, McGill University, Macdonald College, Que., Canada. Journal Series No. 339.

Experimental

One hundred and twenty purebred Yorkshire pigs were weaned at 56 days of age, and started on test at initial weights of 35–40 lb. The experiment was designed to extend over two farrowing seasons in order to account for any differences between winter and summer finished pigs. During the growing period, from 35 to 110 lb. liveweight, all pigs were full-fed a 16% protein ration consisting of barley and a suitable protein-mineral supplement. During the finishing period, from 110 to a market weight of 200 lb., the same ration was fed, except that the level of protein was reduced to 13%. Half of the sixty pigs from each farrowing season, divided equally as to sex, were restricted in feed intake during this latter period, while the remaining animals continued on full feeding. The allotment of these pigs in indicated in table 1.

The individually-penned animals were fed three times daily during the growing period, and twice daily during the finishing period. Until they weighed 110 lb. all pigs received 15 ml. per day of a cod-liver oil concentrate.

Feed and liveweight records were kept for each pig throughout the test. Pigs were marketed individually as they reached 200 lb liveweight. Following slaughter, each carcass was graded and measured by Canadian government graders under standards of the Dominion Government Hog Carcass Grading Policy. In addition, a section from the right side of the carcass extending from backbone to belly was taken between the third and fourth lumbar vertebrae. A planimeter was used to determine from tracings taken from the frozen sections 1) the surface area of the cross section of the loin muscle (longissimus dorsi) and 2) the percentage which the surface area of the lean parts of the rasher was of the total area of the full bacon rasher. These measurements have been found to be correlated significantly with the lean-fat proportions of the pig carcass.

Results and Discussion

The effects of season and of restricted versus full feeding on gain and feed consumption of pigs, and on the excellence of the bacon carcasses produced are indicated in table 1.

It should first be noted that the average daily feed intake of the four groups of pigs up to the 110 lb. mark was approximately the same. After that time the winter-finished pigs were restricted so that feed intake was cut from a daily allowance under full feeding by 2 lb. per

TABLE 1. EFFECTS OF SEASON AND OF RESTRICTED *VS.* FULL FEEDING FROM 110–200 LB. LIVEWEIGHT ON GAIN AND FEED CONSUMPTION OF PIGS, AND ON THE EXCELLENCE OF BACON CARCASS PRODUCED

Feeding Regime		Gain and Feed Data				Carcass Data			
Season	Rate	Daily Feed	Daily Gain	Feed per Pound of Gain	Time from 35–200 lb.	Depth of Neck Fat	% Lean in Bacon Rasher	Area or Loin Muscle	% of Grade A Carcasses
		(lb.)	(lb.)	(lb.)	(days)	(in.)	(%)	(sq. in.)	(%)
Winter finished (60 pigs)	Full feed	8.3(4.6)[1]	1.72(1.25)[1]	4.8	102	1.8	41.0	4.8	58
	Restricted feed	6.3(4.5)	1.27(1.26)	5.0	119	1.6	45.2	5.2	70
Summer finished (60 pigs)	Full feed	7.3(4.7)	1.74(1.27)	4.2	103	1.9	39.6	4.7	38
	Restricted feed	6.3(4.9)	1.50(1.33)	4.2	109	1.8	40.3	5.2	34
Necessary Diff. P of 0.05		0.3	0.11	...	2	0.1	2.0	0.3	..

[1] Figures in parentheses indicate average daily feed intake and average daily gain of corresponding pig groups during the growing period (35–110 lb.).

day. The pigs on restricted feeding, fed the following summer, were given the same daily allowances that the winter-fed restricted pigs received, and the others were full-fed as planned. However, it was found that the summer-finished full-fed pigs consumed one pound per day less feed than the comparable winter-finished group. The result was that, relatively, the restriction was just one-half as severe with the summer fed pigs. While unintentional, this difference in restriction served to emphasize the effects of rate of gain on carcass characteristics.

The average daily gains of the four groups of pigs, up to the weight of 110 lb., were quite similar and were normal according to our expected gain figures for pigs of these ages and weights. However, from 110 lb. to market weight, the effects of restricted feeding were in evidence. The result of feed restriction on the winter finished pigs was an average reduction in growth rate of 0.45 lb. per day during the last 90 lb. of gain—sufficient to cause an increase in the total feeding period of about 2 weeks.

The summer-finished full-fed pigs, although they consumed on the average one pound of feed less per day, actually gained to the same extent as those full-fed during the winter. This probably was the effect of cold weather on gains in relation to feed intake. The restricted summer-finished pigs, receiving the same daily feed allowance as those similarly-fed in the winter, gained about one-quarter of a pound more per day than the restricted winter-finished pigs. The reduction in rate of gain was proportional to the extent of feed restriction.

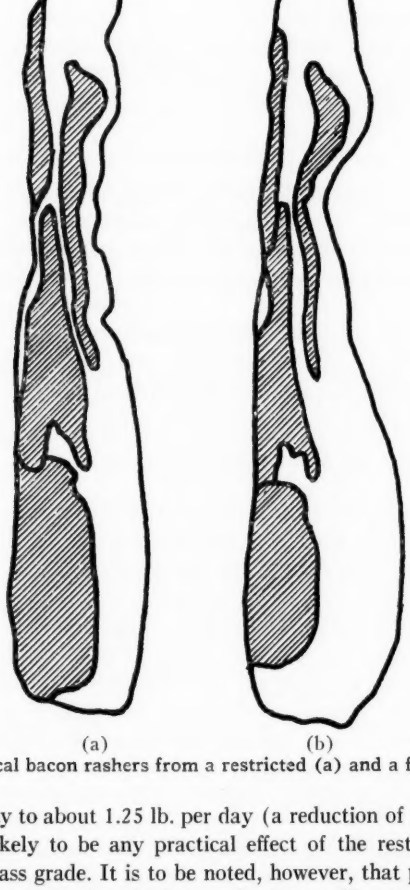
It is interesting to observe that regardless of finishing season, feed efficiency, expressed as amount of feed required per pound of gain, was equal for the full-fed or restricted groups.

Insofar as fatness is concerned, a reduction of 0.2 inch in neck fat was sufficient to cause a significant change in overall fatness in the restricted winter-finished carcasses. The proportion of lean in the bacon rasher increased in these pigs by four percentage units. There was no change in this respect in the summer-finished pigs resulting from feeding practice. Restricted feeding increased the size of the loin muscle both in the winter and summer groups. Typical rasher tracings from a restricted and a full-fed hog are shown in figure 1.

As a consequence of the reduction in fat, there was a significant change in carcass grade. For the full-fed, winter-finished pigs, 58% graded A, whereas 70% of the comparable pigs on restricted feed intake attained this grade. With the full-fed, summer-finished pigs, the

percentage of A carcasses was low (38%), and was not at all improved by the restricted feeding.

This latter result can be interpreted to mean that unless the restriction in feeding can result in a decline in growth rate from a normal



(a) (b)

Figure 1. Typical bacon rashers from a restricted (a) and a full-fed (b) hog.

1.70 lb. per day to about 1.25 lb. per day (a reduction of roughly 25%), there is not likely to be any practical effect of the restriction of feed intake on carcass grade. It is to be noted, however, that pigs fed during warm weather require less feed to make "normal" gains. Thus reduc-

tion in rate of gain rather than any fixed restriction of feed intake is the practical guide which should be followed.

At this point it should be indicated that it probably makes little difference what causes the reduction of weight gains during the finishing period insofar as its effect on carcass fatness is concerned. Restriction of feed is obviously only one way of effecting this reduction in growth rate. Season of year, through its effect on the proportion of the ration needed for maintenance, can also be a contributing factor. Theoretically, a reduction in the digestibility of the finishing ration by the introduction of crude fibre should be a more practical way of improving carcass quality under group feeding.

Conclusions

A restriction of feed intake during the finishing period increased the quality of the hog carcass for bacon by reducing fat deposition during that period. The actual size of the muscle area in the rashers was increased as well as the percentage of lean.

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IMPROVEMENT OF BACON CARCASS QUALITY BY THE INTRODUCTION OF FIBROUS FEEDS INTO THE HOG FINISHING RATION

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IN this laboratory it was found that a restriction of feed intake during the finishing period (110–200 lb.) increased the quality of the hog carcass for bacon by reducing fat deposition during that period (Crampton *et al.*, 1954). In practice, uniform restriction of feed intake for hand-fed groups of pigs is difficult, and impossible if self-feeding is carried out. It would appear that reducing growth rate in pigs during the finishing period could be accomplished more conveniently by reducing the usable energy portion of the ration. This latter reduction presumably could be effected by the introduction into the ration of feeds high in crude fiber.

The experiments to be described were designed to test the suitability of introducing certain fibrous feeds into the hog finishing ration as a means of improving carcass quality through a reduction of digestible energy.

Experimental

The experiment consisted of three separate trials and in each case the animals used were divided equally as to sex and allotted at random to individual pens for feeding. In Trials 1 and 3, half the pigs were summer-finished and half winter-finished; in Trial 2, all pigs were summer-finished. The pigs were weaned at 56 days of age and started on the growing rations at an age of 65 to 70 days. A standard protein-mineral supplement constituted 15% by weight of each ration fed up to 110 lb. live weight, and was reduced to 10% by weight for the finishing rations (110–200 lb. live weight). The pigs were allowed all they would readily consume of their respective rations throughout the trials. They were marketed individually as they reached 200 lb. live weight.

Feed and live weight records were kept for each pig throughout the experiments. Following slaughter, each carcass was graded and

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measured by government graders under standards of the Dominion Government Hog Carcass Grading Policy. The area of the loin muscle and the percentage lean in the bacon rasher were determined as described by Crampton *et al.* (1954). Procedures specific for the separate trials were as follows.

Trial 1

Ninety-six purebred Yorkshire pigs were used. Half the animals received a basal ration containing wheat and the other half an oat basal ration until 110 lb. live weight. At this time, a further division was made so that, within each subgroup of 48 pigs, sixteen were fed to a market weight of 200 lb. on a basal ration composed of wheat, sixteen received a basal ration consisting of 50% wheat plus 50% alfalfa, and the remaining sixteen received an all-oat basal ration.

Trial 2

Forty-eight purebred Yorkshire pigs were used. All animals received a barley basal ration until 110 lb. live weight. At this time, the pigs were sub-divided so that sixteen continued to a market weight of 200 lb. on their original basal ration, sixteen received a basal ration consisting of 72% barley plus 28% wheat bran, and the remaining sixteen received a basal ration consisting of 50% barley plus 50% wheat bran.

Trial 3

Ninety-six purebred Yorkshire pigs were used. All animals received a barley basal ration until 110 lb. live weight. At this time, the pigs were sub-divided so that thirty-two continued to a market weight of 200 lb. on their original basal ration, thirty-two received a basal ration consisting of 81% barley plus 19% wild oats, and the remaining thirty-two received a basal ration consisting of 72% barley plus 28% wild oats.

Results

The effect of the addition of various fibrous feeds to the hog finishing ration on rate of gain, feed intake and carcass quality is summarized in table 1.

Before considering in detail the results of this experiment, it should

TABLE 1. THE EFFECT OF THE ADDITION OF VARIOUS SOURCES OF CRUDE FIBRE TO THE HOG FINISHING RATION (110–200 LB.) ON RATE OF GAIN, FEED INTAKE AND CARCASS QUALITY

Trial No.	No. of Animals	Basal Ration Components	Daily Gain	Daily Feed Intake	No. of Days Fed (115–200 lb.)	Area Loin Muscle	Maximum Shoulder Fat	Maximum Loin Fat	% Lean in Bacon Rasher	% Grade A Carcasses
		(% of total ration)	(lb.)	(lb.)	(days)	(sq. in.)	(in.)	(in.)	(%)	(%)
	32	90% wheat	1.60	6.7	56	3.8	1.91	1.56	34.4	50
1	32	45% wheat plus 45% alfalfa	1.13	7.4	79	4.3	1.53	1.12	45.7	97
	32	90% oats	1.50	7.8	60	3.9	1.66	1.27	40.1	90
		Nec. Diff. (P of 0.05)	0.10	0.3	5	0.3	0.09	0.28	2.8	..
	16	90% barley	1.58	6.5	57	3.8	1.80	1.44	40.9	78
2	16	65% barley plus 25% bran	1.55	6.2	57	4.0	1.57	1.34	43.7	93
	16	45% barley plus 45% bran	1.29	6.2	68	4.2	1.56	1.29	51.5	93
		Nec. Diff. (P of 0.05)	0.18	0.6	8	0.3	0.13	0.12	3.0	..
	32	90% barley	1.55	7.3	58	3.9	1.88	1.59	42.0	48
3	32	73% barley plus 17% wild oats	1.64	7.5	54	3.9	1.82	1.58	42.6	47
	32	65% barley plus 25% wild oats	1.53	7.3	59	4.0	1.79	1.51	44.2	62
		Nec. Diff. (P of 0.05)	0.12	0.5	4	0.2	0.09	0.12	2.2	..

be noted here that any failure of carcasses to attain A grading was due exclusively to excessive fatness.

When oats and wheat were compared as basal ration components in the hog finishing ration, it was found that oats brought about a significant decrease in rate of gain and a significant increase in feed intake. The marked increase in percentage of Grade A carcasses associated with the oat basal ration was the result of significant decreases in shoulder and loin fat, and a significant increase in percentage lean in the bacon rasher. The effect of feeding a basal ration composed of equal parts of wheat and alfalfa was to decrease rate of gain significantly, while feed intake and length of feeding period were both increased significantly. That the percentage of top quality carcasses was almost doubled on the alfalfa-containing ration was a direct reflection of the greater proportion of lean to fat in the carcasses produced.

The addition of either 25 or 45% wheat bran to a ration, the basal portion of which consisted of barley, resulted in a considerable improvement in carcass quality. In comparing the 25 and 45% level of bran additions to the ration, the smaller reduction in proportion of fat to lean in the carcasses on the 25% level was accompanied by a non-significant decrease in rate of gain, and by a similar length of feeding period. On the other hand, the large reduction in proportion of fat to lean in the carcasses on the 45% level was accompanied by a significant decrease in rate of gain, and by a significant increase in length of feeding period.

When wild oats were added at levels of 17 and 25% to a ration consisting of barley plus protein-mineral supplement, carcass improvement was noted only at the higher level of wild oat addition. A significant decrease in shoulder fat and a significant increase in percentage lean in the bacon rasher were found for the ration containing 25% wild oats. Rate of gain, feed intake and length of feeding period were not affected at the 25% level. The proportion of fat to lean was unchanged in the carcasses of pigs fed the ration containing 17% wild oats. A non-significant increase in rate of gain for these pigs resulted in a significantly shorter feeding period.

Discussion

A "dilution" of the digestible energy of the hog finishing ration with fibrous feeds supplied in the form of alfalfa, wheat bran and wild oats, was effective in enhancing bacon carcass quality. Our original

finding that such an improvement was accompanied by a decreased rate of gain (Crampton *et al.*, 1954) was not borne out uniformly in this experiment. This was illustrated by the fact that, when either 25% wheat bran or 25% wild oats was added to a ration whose basal portion consisted of barley, increases were observed in the percentage of Grade A hogs produced, while rate of gain, feed intake and length of feeding period were unaffected. On the other hand, an improvement in carcass quality was accompanied by the expected decrease in rate of gain and increase in length of feeding period when, in the basal portion of finishing rations, alfalfa replaced half the wheat, oats replaced all the wheat, or when wheat bran replaced half the barley.

We have no explanation at the moment for the improvement in carcass quality that obviously was not directly associated with a decreased rate of gain. Presumably, other factors inherent in the specific ration combinations were exerting an effect on the extent of fat deposition in the body.

Summary

Quality of the bacon carcass can be improved by "diluting" relatively highly digestible rations with fibrous feeds during the finishing period.

Bacon carcass improvement was accompanied by a decrease in rate of gain and an increase in length of feeding period when one-half of a high energy basal ration was replaced by either alfalfa or wheat bran, or when the basal portion of the ration consisted entirely of oats.

Increases in the percentage of Grade A carcasses were also obtained when a portion of a high energy basal ration was replaced by either wheat bran or wild oats, so that the total ration consisted of 25%, by weight, of either of the fibrous feeds. In these cases, however, the improvement was not associated with any change in rate of gain, feed intake or length of feeding period.

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THE INFLUENCE OF VITAMIN B_{12} AND AUREOMYCIN SUPPLEMENTATION IN THE RATION ON THE VITAMIN B_{12} ACTIVITY OF PORK MUSCLE [1, 2]

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University of Wisconsin [3]

CONSIDERABLE research has been done to determine the effect of the animal protein factor (APF), vitamin B_{12}, and aureomycin supplementation on the rate of gain and feed efficiency of swine. Luecke *et al.* (1949) reported that weanling pigs that were fed a corn and soybean diet, supplemented with 0.5 percent vitamin B_{12} concentrate, gained weight at a significantly greater rate than pigs fed the same basal without the supplement. Colby and Ensminger (1950) reported that no advantage was shown by adding a vitamin B_{12} concentrate, crystalline vitamin B_{12} (injected), and APF concentrate, or alfalfa and fish meal to a purified basal ration for the growing pig. Cunha *et al.* (1950) reported that efficient utilization of protein by pigs was obtained only when the diet was supplemented with APF.

The purpose of the present investigation was to determine the effect of supplementation of the ration with vitamin B_{12}, aureomycin, and aureomycin and vitamin B_{12} on the amount of vitamin B_{12} deposited in the tissues of hogs. Earlier work by Lewis *et al.* (1949a) showed that meat, cheese, milk, and egg yolk were relatively good sources of vitamin B_{12}. These workers reported levels of 2.2–3.6 mcg. per 100 gm. of vitamin B_{12} in pork shoulder. Register *et al.* (1949) reported that beef samples contained twice as much vitamin B_{12} as a normal pork sample. These workers also reported a wide variation in the B_{12} content of pork samples and offered the explanation that swine, being monogastric animals, may not be supplied with ample quantities of vitamin B_{12}. Lewis, Register, and Elvehjem (1949b) showed that the inclusion of B_{12} concentrate in the animal's diet caused an increase in the quantity of B_{12} in the organs and tissues of the rat. Meyer *et al.* (1952) working with rats reported that pork diets impaired lactation and hindered conception. This was not observed in the pork group supplemented with vitamin B_{12}. Scheid, Andrews, and Schweigert

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(1951a) investigated the storage of vitamin B_{12} in rat liver after feeding rats graded amounts of crystalline vitamin B_{12} or crude supplements. These workers reported that the vitamin B_{12} potency was shown to increase as the level fed was increased. Kline *et al.* (1952) reported that pigs fed vitamin B_{12} as a supplement to a semi-purified ration had higher B_{12} concentrations in the tissues.

Experimental

In Experiment I 96 feeder pigs, averaging 45 lb., were randomly distributed into 12 lots of eight pigs each. All lots were fed a corn, soybean oil meal, alfalfa meal ration. High, intermediate, and low levels of protein were fed to each of three groups of four lots each. The initial protein levels for the three groups were 20, 17, and 14 percent respectively. From 150 to 210 lb. the protein was reduced to 12, 10, and 9.5 percent. The four lots within each protein level were fed as follows: Lot 1, control ration; lot 2, control plus 20 mcg. of crystalline vitamin B_{12} per kg. of air-dry ration; lot 3, control plus 20 mg. of aureomycin per kg. of ration; lot 4, control plus aureomycin and vitamin B_{12} in combination at the levels fed in lots 2 and 3.

When the average weight of a lot reached 213 lb., the pigs were slaughtered packer style, and after a 24–48 hour chill the right side was measured and cut.

Samples of the longissimus dorsi muscle were removed just posterior to the last rib, frozen, and stored until prepared for assay. The method of Scheid and Schweigert (1951b) was used to prepare the tissues for assay.

The method of Thompson, Dietrich, and Elvehjem (1950), using *Lactobacillus leichmannii* ATCC No. 4797 as the test organism, was used to determine the vitamin B_{12} activity of the samples.

In experiment II 56 weanling pigs of mixed breeding averaging 41 lb. in weight were divided among lots of seven pigs each on the basis of weight, breed, and sex. Four of the eight lots were assigned at random to each of two protein levels, 18 and 14 percent. When the individual lots averaged 120 lb. in weight, the protein levels were reduced to 14 percent and 10.5 percent respectively. The four lots within each protein level were fed as follows: Lot 1, control ration, a corn, soybean oil meal, alfalfa meal ration; lot 2, control plus 20 mg. aureomycin per kg. of ration; lot 3, control plus 3.3 mg. riboflavin, 11.0 mg. niacin, 13.21 mg. calcium pantothenate, and 20 mcg. of vitamin B_{12} per kg. of ration (referred to as the B-vitamin mix); lot 4, control plus aureo-

mycin and vitamins in combination at levels fed in lots 2 and 3. Samples of the longissimus dorsi muscle were again assayed for vitamin B_{12} activity using the A.O.A.C. collaborative microbiological assay.

In addition to assaying for vitamin B_{12} activity of the muscle tissue, the percentage of moisture and fat was determined by a modified A.O.A.C. method. The vitamin B_{12} activity was then adjusted to a moisture-free fat-free basis. The data were analyzed for significance using the analysis of variance method of Snedecor (1946).

Results and Discussion

A comparison of the vitamin B_{12} activity of the tissues between the high, medium, and low protein levels of experiment I shows that the level of protein fed did not affect the treatment of the lots receiving vitamin B_{12}, aureomycin, or aureomycin and B_{12} significantly when compared to the basal lots (table 1).

TABLE 1. INFLUENCE OF VITAMIN B_{12} AND AUREOMYCIN SUPPLEMENTATION IN THE RATION ON THE VITAMIN B_{12} CONTENT OF PORK MUSCLE—EXPERIMENT I

Micrograms/100 gm. dry

Protein Level	Lot 1 Basal	Lot 2 Basal+B_{12}	Lot 3 Basal+ Aureomycin	Lot 4 Basal+B_{12} +Aureomycin
High (20%)	0.72	1.15	0.17	0.61
Medium (17%)	0.34	1.02	1.02	0.55
Low (14%)	0.41	1.51**	0.31	0.72
Average	0.49	1.23**	0.50	0.63

** Significant at 1% level.

In experiment II, using a B-vitamin mix in place of crystalline vitamin B_{12} alone, the level of protein fed had a significant effect upon the deposition of vitamin B_{12} in the muscle. The pigs fed at the lower level of protein (14%) deposited more vitamin B_{12} in the muscle than did those fed at the higher (18%) level (table 2).

In experiments I and II the lots receiving vitamin B_{12} alone, or as the vitamin mix, responded with an increase in vitamin B_{12} activity of the muscle. In experiment I the increased deposition of B_{12} was highly significant at the low protein level and approached significance at the medium and high protein levels. In experiment II the addition of the B-vitamin mix, alone or in combination with aureomycin, resulted in

an increased deposition of vitamin B_{12} in the muscle which was highly significant.

The addition of aureomycin to the basal ration in experiment I, either alone or in combination with B_{12}, reduced the B_{12} activity of

TABLE 2. INFLUENCE OF B-VITAMIN AND AUREOMYCIN SUPPLEMENTATION IN THE RATION ON THE VITAMIN B_{12} CONTENT OF PORK MUSCLE—EXPERIMENT II

Micrograms/100 gm. dry

	Lot 1	Lot 2	Lot 3	Lot 4
Protein Level	Basal	Basal+ Aureomycin	Basal+ B-Vitamin Mix	Basal+ B-Vitamin+ Aureomycin
High (18%)	0.22	0.18	0.54**	0.71**
Medium (14%)	0.46	0.29	0.94**	0.85**
Average	0.34	0.24	0.74**	0.78**

** Significant at 1% level.

the muscle except at the medium protein level. In experiment II the addition of aureomycin to the lots receiving the B-vitamin mix did not depress the deposition of vitamin B_{12} in the muscle. The interaction of aureomycin and vitamin B_{12} noted in experiment I suggests several metabolic mechanisms.

1. Aureomycin is an antagonist of vitamin B_{12}.
2. Aureomycin reduces the amount of vitamin B_{12} absorbed.
3. Aureomycin and vitamin B_{12} may form conjugates in metabolism.
4. The antibiotic aureomycin is also deposited in the tissues after a prolonged period of supplementation of the ration.

In experiments I and II the percentage of fat in the lean tissue was not affected by either the B vitamins or aureomycin supplementation. The level of protein fed appeared to exert a greater influence upon deposition of intramuscular fat than did the treatment of vitamins or antibiotics (table 3). The high level of protein in both experiments I and II had the lowest percentage of intramuscular fat while the lower levels of protein had the highest percentage of intramuscular fat. These differences were highly significant.

Summary

The results of the influence of vitamin B_{12} and aureomycin supplementation in the ration on the vitamin B_{12} activity of pork muscle have been investigated.

The pigs which received a ration supplemented with vitamin B_{12} responded with an increased vitamin B_{12} activity of the muscle.

In experiment I the feeding of aureomycin with or without supplements of B_{12} lowered the concentration of vitamin B_{12} in pork muscle except at medium protein level.

TABLE 3. PERCENTAGE INTRAMUSCULAR FAT IN PORK MUSCLE OF HOGS FED AT VARIOUS PROTEIN LEVELS WITH AUREOMYCIN AND VITAMIN B_{12}

	Treatment							
	Basal		Basal+ B-Vitamins		Basal+ Aureomycin		Aureomycin+ B-Vitamins	
Protein Level	Exp. I	Exp. II	Exp. I	Exp. II	Exp. I	Exp. II	Exp. I	Exp. II
High (20%)	4.40	4.70	4.20	3.97	3.40	4.20	4.16	4.70
Medium (17%)	5.50	6.30	5.80	7.10	5.50	8.00	4.49	7.70
Low (14%)	8.50	....	7.30	....	7.70	....	7.80	....

In experiment II the depression of B_{12} deposition in the muscle tissue was again found in the lots receiving aureomycin alone, yet in this experiment the interaction of aureomycin and B_{12} was not present.

The deposition of intramuscular fat under the conditions of these two experiments appears to be an inverse response to the level of protein fed rather than to treatment with vitamin B_{12} and antibiotic.

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THE EFFECTS OF RATIONS CONTAINING ANTIBIOTICS AND TRACE MINERAL SALT ON THE CHEMICAL COMPOSITION AND PHYSICAL CHARACTERISTICS OF PORK CARCASSES

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THE use of antibiotics in rations for swine and poultry has received widespread publicity since early in 1950 when it was first reported that aureomycin stimulated growth of the pig (Jukes *et al.*, 1950). Since that time, many experiment stations have presented a great amount of evidence showing that antibiotics increase rate of gain and feed efficiency of pigs during the growing-fattening period from weaning to market weight. A review of these experiments by Wallace *et al.* (1952) revealed that aureomycin, terramycin, streptomycin, penicillin, and bacitracin were all effective growth stimulants. However, the effects of antibiotic supplemented rations on the carcasses of these rapid gaining and fast growing pigs have not received a great amount of study, and the results of the experiments which have been reported are somewhat contradictory.

The objective of this experiment conducted at the South Dakota Agricultural Experiment Station during 1951–52 was to determine the effects of rations containing aureomycin, terramycin, and trace mineral salt, supplied during all or part of the growing-fattening period, upon the chemical composition and physical characteristics of the carcasses from 200-pound market hogs fed in dry lot.

Materials and Methods

A total of forty-six barrows averaging 209 lb. was slaughtered to obtain the data used in this study. These barrows were from an experiment reported by Wilson (1952) which showed more rapid and efficient gains by antibiotic-fed pigs. They were from six lots and represented four breeds, namely: Duroc, Hampshire, Poland China and Spotted Poland China. Weanling pigs were initially divided into six lots so that each lot contained fifteen pigs and an equal number of the same breed. This allotment was such that eight barrows could be slaughtered from each lot. Death losses and failure to reach slaughter weight

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within the time allowed for the experiment prevented the slaughter of two barrows from Lot 1 and one barrow from Lot 6; one additional barrow was slaughtered from Lot 2.

All barrows were fed and housed on concrete at the college swine farm and received the following rations from weaning until immediately preceding slaughter. Lot. 1, the control lot, received a basal ration of shelled yellow corn; a protein supplemental mixture of 42 parts of soybean meal, 30 parts of tankage, and 28 parts of ground, sun-cured alfalfa hay; and a simple mineral mixture. The pigs in Lot 2 received the same ration as those in Lot 1, except that three parts of the ground, sun-cured alfalfa hay in the protein supplemental mixture were replaced with three parts of a vitamin B_{12}-aureomycin supplement (Aurofac) [2] until the pigs reached market weight. The pigs in Lot 3 were fed the same ration as those in Lot 2 until they reached 125 lb., after which time they received the same ration as Lot 1.

In Lots 4 and 5, one part of the alfalfa hay in the protein supplement was replaced with one part of a terramycin supplement (TM-5).[3] Lot 4 received this ration until the pigs reached market weight, and Lot 5, until the pigs reached about 125 lb., after which they received the same ration as Lot 1. The pigs in Lot 6 received the same ration as Lot 1 with the exception that the common salt of the simple mineral mixture was replaced by a commercial trace mineral salt.[4]

All barrows used in this study were removed from the various lots as soon as possible after reaching 200 lb. in weight. Only a short period of 2–3 hours was allowed for shrink before they were slaughtered in the college meats laboratory. All carcasses were dressed according to a modified packer style. The carcass, including the head, was split in half and the head, ham facings, and leaf fat were loosened but not removed. Dressing percentage was calculated on the basis of the entire carcass after a twenty-four hour chill at a temperature of 32–34° F.

Subsequent to chilling, the physical characteristics of the carcasses were determined by taking such measurements as length of carcass from first rib to point of aitch bone, and backfat thickness at the first and last ribs and at the last lumbar vertebra. The right side of each carcass was then cut into wholesale cuts according to the standard procedure as outlined in the report of proceedings of the Reciprocal Meat Conference (1951) and the weight of each cut recorded. The

[2] Supplied by Lederle Laboratories, Pearl River, N. Y.
[3] Supplied by Chas. Pfizer and Company, Chicago, Ill.
[4] A commercial trace mineral salt specified to contain the following: Manganese 1.36%; Iodine 0.038%; Cobalt 0.013%; Iron 0.48%; Copper 0.048%; Salt 93%; not specified 5.061%.

four lean cuts (ham, loin, boston butt, and picnic shoulder) and also the trimmings were individually-separated into lean, fat, and bone. Weights of these constituents were made for the four lean cuts and trimmings.

Representative samples of the lean and fat from the ham, loin, boston butt, picnic shoulder, and trimmings of each carcass were chemically-analyzed for moisture, protein, and fat. The samples were taken after grinding several times through a 1/8-inch chopping plate. Additional homogenation of the samples was accomplished by repeated grindings through a 3/32-inch plate. The lean of the boston butt and picnic shoulder was ground together and treated as one sample designated shoulder lean. The fat from the above two cuts was treated in a similar manner and designated shoulder fat.

Results

The physical characteristics of the carcasses are presented in table 1. These data are in rather close agreement with those presented by

TABLE 1. SUMMARY OF PHYSICAL MEASUREMENTS

Items Compared	Lot I Basal	Lot II Aureomycin Vitamin B_{12} to 200 lb.	Lot III Aureomycin Vitamin B_{12} to 125 lb.	Lot IV Terramycin to 200 lb.	Lot V Terramycin to 125 lb.	Lot VI Trace Mineral Salt
Number of pigs	6	9	8	8	8	7
Av. live weight at slaughter, lb.	208.8	211.7	210.2	207.9	207.2	207.4
Av. dressing percent	74.4	77.0	76.7	76.4	76.6	76.8
Av. length of carcass, inches [1]	28.9	28.3	28.1	28.8	28.8	28.7
Av. depth of back fat inches [2]	1.78	1.94	1.97	1.82	1.87	1.79
Av. weight of four lean-cuts, lb.	32.9	33.5	33.0	33.3	34.0	33.0
Av. weight of fat cuts, lb.[3]	12.0	13.5	13.4	12.9	12.6	12.8
Av. percent of lean in lean cuts	59.2	59.2	58.2	60.0	58.7	58.7
Av. percent of fat in lean cuts	26.2	26.7	27.3	25.7	26.4	27.5
Av. percent of bone in lean cuts	13.8	13.6	14.2	14.3	14.5	13.4

[1] Measurement made from first rib to point of aitch bone.
[2] Measurements taken at first and last rib and last lumbar vertebrae.
[3] Includes backfat and clear plate.

Terrill *et al.* (1951) and Robison *et al.* (1952). The minor variations in the weight of lean cuts do not conform with results obtained by Wilson *et al.* (1952) in which the addition of vitamin B_{12} and aureomycin, separately, or in combination, to rations with low and medium levels of protein significantly increased the percentage of lean cuts.

It may be noted from the above table that small differences existed in the means of two of the more important measurements—namely, dressing percent and backfat thickness. The pigs fed antibiotics had a slightly greater average depth of backfat and a higher average dressing percent than those not fed antibiotics. Although differences were not statistically significant, the data indicate a trend for the antibiotic-fed pigs to have a fatter carcass. However, the increase in backfat thickness from 1.78 in. to 1.97 in. only partially approaches the increases reported by Beeson (1952). Only small variations in the length of the carcasses and weight of the four lean cuts are shown and also there are only minor differences in the percentage of lean, fat and bone in the lean cuts. The average weight of the fat cuts from the various lots ranged from 12.0 to 13.5 lb., but this difference was not large enough to be significant.

The physical measurements data do not show any differences between the groups which received the antibiotic supplements during all of the growing-fattening period and those which received the antibiotic until they weighed 125 lb. Similarly, the chemical composition data do not show any differences due to the length of time the pigs received the antibiotics. All of these data are not in agreement with the findings of Bowland *et al.* (1952) who concluded that antibiotic supplements had a tendency to reduce carcass grades. An interesting observation during this experiment was the fact that the cut surfaces of the muscle tissues of the hams and loins from all antibiotic-fed pigs appeared to be somewhat lighter in color and more moist than the corresponding tissues from the pigs which did not receive the antibiotics.

The effects of aureomycin, terramycin, and trace mineral salt on the moisture, protein, and fat content of the various areas of lean tissue are shown in table 2. Corresponding information relative to the fatty tissues is presented in table 3. None of the differences between treatments listed in table 2 were significant. However, an interesting observation is the comparatively wide variation in moisture and fat content of the lean tissue from the various sections of the carcass.

A computation of weighted averages for moisture content of lean

in the ham, loin, and shoulder revealed percentages of 68.5, 62.3, and 65.4 respectively, indicating that the lean or muscle tissues of a pork carcass will vary approximately 10 percent in moisture content, depending upon their location. This variation in moisture content may account for the greater shrinkage of hams during the curing and smoking process as compared to a similar quantity of boneless pork loins or butts.

TABLE 2. RESULTS OF CHEMICAL ANALYSES OF LEAN TISSUE SAMPLES

Items Compared	Lot I Basal	Lot II Aureomycin Vitamin B_{12} to 200 lb.	Lot III Aureomycin Vitamin B_{12} to 125 lb.	Lot IV Terramycin to 200 lb.	Lot V Terramycin to 125 lb.	Lot VI Trace Mineral Salt
No. of analyses	6	9	8	8	8	7
Av. moisture content of lean tissue	%	%	%	%	%	%
Ham	69.6	68.3	68.7	68.0	68.5	67.9
Loin	61.1	62.4	61.6	62.3	63.2	62.7
Shoulder	64.3	65.8	65.1	65.9	65.6	65.6
Trimmings	62.0	60.8	58.8	59.3	61.1	61.6
Av. protein content of lean tissue						
Ham	20.2	19.4	19.8	19.7	20.1	19.3
Loin	20.0	19.4	19.6	18.9	20.4	20.2
Shoulder	18.1	18.3	18.6	18.0	18.6	18.3
Trimmings	19.5	18.4	18.9	18.0	19.7	19.3
Av. fat content of lean tissue						
Ham	7.5	8.8	8.8	9.3	8.3	9.7
Loin	16.5	14.9	17.6	16.5	13.3	13.3
Shoulder	15.4	13.2	13.9	14.8	11.6	12.8
Trimmings	14.6	18.2	19.4	19.9	16.1	16.6

An even greater variation existed in the fat content of the lean from the various sections. The weighted averages for the fat content of the lean from ham, loin and shoulder were 8.8, 15.3 and 13.5 percent respectively. These averages show a variation in total moisture of approximately seventy-five percent in the three types of lean and would indicate a much lower caloric value for ham lean. The data also show a rather consistent inverse relationship between the fat and moisture content of the various sections.

Table 3 contains the only comparison which showed a significant difference when subjected to statistical analysis. This difference existed in the protein content of the ham fat. The protein content of the fat tissue in the ham was greater in the control lot than in the hams of the pigs which received antibiotics or trace mineral salt. Although not significant, the data seem to indicate a trend for the basal lot to have less moisture in the fat tissue from the ham, loin,

TABLE 3. RESULTS OF CHEMICAL ANALYSES OF FAT TISSUE SAMPLES

Items Compared	Lot I Basal	Lot II Aureomycin Vitamin B_{12} to 200 lb.	Lot III Aureomycin Vitamin B_{12} to 125 lb.	Lot IV Terramycin to 200 lb.	Lot V Terramycin to 125 lb.	Lot VI Trace Mineral Salt
No. of analyses	6	9	8	7	8	7
Av. moisture content of fat tissue	%	%	%	%	%	%
Ham	16.5	18.3	17.7	16.8	17.6	18.0
Loin	13.7	17.5	16.6	16.5	17.1	17.2
Shoulder	17.0	19.5	19.0	18.6	18.9	18.8
Trimmings	14.1	14.2	13.0	13.2	13.6	12.5
Av. protein content of fat tissue						
Ham *	7.3	6.2	5.7	6.2	6.6	5.6
Loin	6.1	5.8	5.3	5.3	5.9	5.9
Shoulder	6.7	6.8	6.4	6.7	7.2	6.6
Trimmings	6.2	5.5	5.5	5.2	5.5	4.9
Av. fat content of fat tissue						
Ham	76.2	75.3	76.7	76.4	75.2	76.6
Loin	80.0	75.1	78.1	77.9	76.6	76.7
Shoulder	76.3	73.3	74.7	74.8	73.8	74.6
Trimmings	79.8	80.3	81.6	81.1	80.0	82.4

* Analysis of variance revealed significant differences between control and treated lots at 5% level.

and shoulder. In all of the antibiotic groups and the trace mineral salt group, the mean percentage of moisture in the fat tissue of the ham, loin, and shoulder is higher than in the fat tissue of the corresponding cuts from the control group. This variation is especially apparent in the loin data in which the average moisture content of the fat tissue of the control group is 2.8 percentage units less than the average of all groups. Although not as apparent, similar differences of 1.1 and 1.7 percent exist in the data for the ham and shoulder, respectively.

Summary and Conclusions

A total of 46 barrows was slaughtered at an average weight of 209 lb. to determine the effects of rations containing aureomycin-vitamin B_{12}, terramycin, and trace mineral salt on the chemical composition and physical characteristics of their carcasses.

The average backfat thickness of the pigs receiving an antibiotic was slightly greater than that of the pigs in the control lot and this increased thickness caused a similar increase in the average weight of fatback and clear plate obtained from these hogs. However, the differences were not great enough to be significant. The average weight of lean cuts and the average percent of lean in the lean cuts was very similar in all groups. There were no apparent differences between the lots as a result of the length of time that the antibiotic supplements were supplied in the ration.

Chemical analyses revealed no differences between the various lots which could be attributed to treatment. A trend toward a higher moisture content of fat seemed to be indicated for the treated lots, but was not significant when the data were analyzed statistically.

It is concluded from this study that aureomycin-vitamin B_{12}, terramycin or trace mineral salt in the growing-fattening ration has no measurable effects on chemical composition of the physically separated carcass or physical characteristics of carcasses from 200 lb. hogs. Similarly, elimination of the antibiotic supplements when the pigs weighed about 125 lb. has no effect on the final carcass characteristics.

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PROTEIN AND AMINO ACID INTAKES FOR OPTIMUM GROWTH RATE IN THE YOUNG PIG

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THE level of dietary protein essential to insure an adequate intake of amino acids is of paramount importance in the nutrition of the young pig. For the suckling pig, sow's milk normally provides approximately 33 percent protein on a dry matter basis according to the studies of Hughes and Hart (1935), Braude *et al.* (1947), Bowland *et al.* (1949) and Heidebrecht *et al.* (1951). However, there is little evidence to indicate that the need of the baby pig for such a high quality protein approaches the level found in sow's milk.

Recently there has been considerable interest in the protein requirement of the weanling pig, although few studies have been conducted with the pig at less than weaning age. Using a vitamin-extracted casein as the sole source of protein, Reber, Whitehair and MacVicar (1953) have reported that a diet containing 41 percent protein produced maximum weight gains and feed efficiency in young pigs from 12 to 24 days of age, and as the pigs approached 8 weeks of age 20 percent protein appeared to be as efficient as higher levels. Sewell *et al.* (1953a) employed a vitamin-extracted casein and an isolated soybean protein supplemented with methionine to study the protein needs of the suckling pig. They found that 16 or 20 percent protein gave slow growth in baby pigs from 2 to 30 days of age. They further noted that 32 percent protein gave fastest growth and most efficient feed utilization, but 24 and 28 percent protein gave relatively satisfactory results.

The investigations described herein were conducted to determine the minimum protein requirement of the young pig (1) at approximately 1 to 4 weeks of age and (2) at 5 to 9 weeks of age, when dried skim milk was employed as the sole source of protein.

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Experimental

Experiment I

The pigs used were of various breeds. They had been nursed by their dams from birth until the initiation of the tests. In every case the dams were fed adequate diets prior to farrowing. The tests were conducted at the University Swine Farm in the baby pig laboratory which was maintained at a proper temperature at all times. Wire-bottom cages approximately 23″×24″ in dimensions were employed. The cage area permitted a somewhat restricted activity particularly during the latter phases of the test.

Feedings were made three times daily (8 a.m., 3 p.m., and 10 p.m.) in small metal troughs placed in the pens. The troughs were washed and disinfected usually on alternate days. During the initial 10 days of the tests the milk diet was heated to about 38° C, thereafter it was usually fed as removed from the refrigerator. In trial 1 the pigs were fed *ad libitum;* whereas, in the remaining trials the equalized feeding technic as described by Mitchell and Beadles (1930) was employed.

The ingredients of the diets employed are presented in table 1.

TABLE 1. COMPOSITION OF DIETS FED
(Experiment I)

Ingredients	Percent
Dried skim milk, spray dried Lactose Dicalcium phosphate [1]	93.29
Corn oil	5.00
Methyl cellulose [2]	1.00
Iodized sodium chloride	0.50
Mineral mixture #11 [3]	0.21
Vitamin mixture #16 [4]	+
Antibiotics [5]	+

[1] Varied to yield the desired protein level (N of dried skim milk × 6.38) and calculated 1.08 percent calcium.

[2] Included in trial 3 only.

[3] Mineral additions per 100.0 pounds of dry matter were: $MgCO_3$, 67.00 gm.; $FeSO_4 \cdot XH_2O$, 22.80 gm; $MnSO_4 \cdot H_2O$, 1.80 gm. $CuSO_4 \cdot 5H_2O$, 1.47 gm.; $ZnCO_3$, 500.00 mg.; and $CoCl_2 \cdot 6H_2O$, 336.00 mg.

[4] Vitamin additions (20% ethanol solution) per 100.0 pounds of dry matter were: aqueous vitamin A, 340,909 U.S.P. units; aqueous irradiated ergosterol, 34,091 U.S.P. units; alpha-tocopherol acetate, 340.9 mg.; vitamin K, 88.6 mg.; ascorbic acid, 1.36 g.; thiamine HCl, 222.7 mg.; riboflavin, 443.2 mg.; pyridoxine HCl, 222.7 mg.; calcium pantothenate, 2.66 g.; inositol, 8.86 g.; choline chioride, 68.17 g.; p-aminobenzoic acid, 886.4 mg.; biotin, 3.40 mg.; niacin, 1.80 g.; folic acid, 17.7 mg.; and vitamin B_{12}, 1.36 mg.

[5] Trial 1—oxytetracycline HCl at 10.0 mg. per pound of dry matter. Trial 2 and 3—equal parts of oxytetracycline HCl, procaine penicillin G, and bacitracin fed to supply 180.0 mg. per pound of dry matter.

The diets were fed as a milk containing 20 percent total solids. The diets were prepared by mixing in order dried skim milk, lactose, corn oil, minerals, vitamins, cellulose, and antibiotics in water at approximately 60° C. Dried skim milk prepared by a low-heat, spray-drying process was employed. The samples used contained from 5.64 to 5.83 percent nitrogen. Since this preparation yielded a stable dispersion of the fat, homogenization was deemed unnecessary. The mixed diet was refrigerated until fed.

The levels of protein fed are indicated in table 2. The pigs were weighed on alternate days and general observations were made at the time of feeding and weighing.

Results. The results of feeding various levels of protein to the baby pig from 3 or 7 days of age to 28 days of age are presented in table 2.

It may be noted that baby pigs survived on a diet containing 10.2 percent protein, although feed consumption, daily gain, and efficiency of feed conversion were suboptimal. Improved performance was observed with each increment in dietary protein level up to 22.4 percent. Protein levels higher than 22.4 percent failed to yield improvement as judged by any of the experimental criteria.

In trials 2 and 3, it was observed that the equalized feeding technic permitted performance equivalent to that obtained with *ad libitum* feeding. In trial 2, levels of 22 or 26 percent protein produced more rapid rates of gain and greater efficiency of feed utilization than 18 percent protein. However, when analyzed with Students "t" test for paired data, only the 22 percent protein level was superior to 18 percent in rate and efficiency of gains (P less than 0.05). Additional observations were obtained by feeding 20, 22, and 24 percent protein in trial 3. A statistical analysis of these data revealed that 22 percent protein (P less than 0.01) and 24 percent protein (P less than 0.05) were both superior to the lower level in rate and efficiency of gain. However, the two higher levels did not differ significantly from each other.

The rate of growth recorded for the pigs from 1 to 4 weeks of age is equal to that of sow-fed pigs at a comparable age. The groups fed adequate levels of protein gained from 0.50 to 0.58 lb. daily on an intake of 0.60 to 0.65 lb. of dry matter. Similar rates of feed conversion have been reported previously.

Experiment II

Pigs which had been fed adequate diets in the preceding and other experiments conducted with synthetic milk diets were converted to

TABLE 2. RESULTS OF FEEDING VARIOUS LEVELS OF PROTEIN
(Experiment I)

Lot No.	Level of Protein [1]	No. of Pigs	Av. Initial Age	Av. Initial Wt.	Av. Final Wt.	Av. Days On Test	Av. Daily Gain	Av. Daily D.M. Consumed	Av. D.M. per lb. Gain
	(%)		(days)	(lb.)	(lb.)		(lb.)	(lb.)	(lb.)
Trial 1	*Ad libitum*								
1	10.2	3	3	3.70	7.83	25	0.17	0.31	1.88
2	14.3	2 [2]	3	3.60	10.60	25	0.28	0.42	1.52
3	18.4	3	3	3.63	14.10	25	0.42	0.52	1.24
4	22.4	3	3	3.67	17.33	25	0.55	0.60	1.10
5	26.5	3	3	3.67	18.10	25	0.58	0.60	1.15
6	30.6	3	3	3.60	15.93	25	0.49	0.63	1.28
Trial 2	Equal-fed								
1	18.0	4	7	4.68	14.30	21	0.46	0.62	1.35
2	22.0	4	7	4.60	16.22	21	0.55	0.62	1.12
3	26.0	4	7	4.82	15.30	21	0.50	0.62	1.24
Trial 3	Equal-fed								
1	20.0	8	7	4.38	14.84	21	0.50	0.65	1.31
2	22.0	8	7	4.65	15.79	21	0.53	0.65	1.23
3	24.0	8	7	4.41	15.84	21	0.54	0.65	1.20

[1] Protein=N×6.38. Determined by calculation for trial 1 and by analysis for trials 2 and 3.
[2] One pig died following severe diarrhea.

a dry diet by feeding combinations of the synthetic milk and dry diet during the fourth week of age. At 5 weeks of age the pigs were divided into trios or quadruplets and allotted at random to the treatments. The pigs were kept in cages 23″×36″ in dimensions. In trial 1 the cages were placed on concrete floors with wood shavings as bedding, and during the remaining tests the cages were placed above the floor on a perforated steel sheet.

A description of the diets employed is presented in table 3. Dried

TABLE 3. COMPOSITION OF DIET FED
(Experiment II)

Ingredients	Percent
Dried skim milk, roller dried Corn Starch Dicalcium phosphate [1]	83.79
Dextrose	10.00
Woodflock	3.00
Corn oil	2.00
Iodized sodium chloride	0.50
Vitamin A & D oil (3000A, 600D)	0.50
Mineral mixture #11	0.21
Vitamin mixture #26 [2]	+
Antibiotic [3]	+

[1] Varied to yield the desired protein level (N of dried skim milk×6.38) and calculated 0.94 percent calcium.

[2] Vitamin additions per 100.0 pounds of dry matter were: thiamine HCl, 222.70 mg.; riboflavin, 443.20 mg.; pyridoxine HCl, 222.70 mg.; calcium pantothenate, 266 gm.; inositol, 8.86 gm.; p-aminobenzoic acid, 886.40 mg.; biotin, 3.40 mg.; nicotinic acid, 1.80 gm.; folic acid, 17.70 mg.; vitamin B_{12}, 1.36 mg.; choline chloride, 68.17 gm.; ascorbic acid, 1.36 gm.; α-tocopherol acetate, 340.90 mg.; and 2-methyl-1, 4-napthoquinone, 88.60 mg.

[3] Oxytetracycline HCl at 10.0 mg per pound.

skim milk prepared by a roller-drying process was used as the source of protein. Samples of the dried skim milk tested 5.64 percent nitrogen. In all tests the equalized feeding technic was used. The levels of protein studied are indicated in table 4. All pigs were fed the diet as a gruel twice daily, except in the dry-feeding phase of trial 3. Dry feeding was conducted by offering in individual self feeders, once daily, a quantity of feed which would be consumed individually by all pigs within the group.

Individual feed records were maintained and live body weights were recorded at weekly intervals.

Results. The results of feeding various levels of protein to the pig from 5 to 9 weeks of age are presented in table 4.

In trial 1 protein levels varying from 16.3 to 25.5 percent failed to produce differences in rate and efficiency of gains. Likewise, in trial 2

the variations in performance were not significant when levels of protein from 12.2 to 16.3 percent were fed.

In trial 3 levels of 10, 12, and 14 percent protein were offered.

TABLE 4. RESULTS OF FEEDING VARIOUS LEVELS OF PROTEIN
(Experiment II)

Trial 1				
Lot No.	1	2	3	4
Level of protein [1] (%)	16.3	19.4	22.4	25.5
No. of pigs	4	4	4	4
Av. initial wt., lb.	23.8	24.6	23.8	24.1
Av. final wt., lb.	59.8	60.5	60.2	59.9
Av. daily gain, lb.	1.28	1.28	1.30	1.28
Av. daily feed intake, lb.	2.89	2.89	2.89	2.89
Av. feed per lb. gain, lb.	2.25	2.26	2.22	2.26
Trial 2				
Lot No.	1	2	3	
Level of protein [1] (%)	12.2	14.3	16.3	
No. of pigs	4	4	4	
Av. initial wt., lb.	20.1	19.9	20.0	
Av. final wt., lb.	58.8	56.6	56.8	
Av. daily gain, lb.	1.38	1.31	1.31	
Av. daily feed intake, lb.	3.03	3.03	3.03	
Av. feed per lb. gain, lb.	2.19	2.31	2.31	
Trial 3				
Lot No.	1	2	3	
Level of protein [2] (%)	10.0	12.0	14.0	
Dry-fed				
No. of pigs	5	5	5	
Av. initial wt., lb.	17.6	18.4	17.9	
Av. final wt., lb.	33.2	36.9	35.7	
Av. daily gain, lb.	0.56	0.66	0.64	
Av. daily feed intake, lb.	1.72	1.72	1.72	
Av. feed per lb. gain, lb.	3.09	2.60	2.70	
Gruel-fed				
No. of pigs	8	8	8	
Av. initial wt., lb.	21.7	21.3	21.5	
Av. final wt., lb.	49.5	52.2	52.6	
Av. daily gain, lb.	0.99	1.10	1.11	
Av. daily feed intake, lb.	2.69	2.69	2.69	
Av. feed per lb. gain, lb.	2.71	2.43	2.43	

[1] Calculated.
[2] By analysis (N×6.38).

Whether the diets were gruel-fed or dry-fed, statistical analysis with Students "t" test for paired data showed that the two higher levels were superior to the 10 percent level as measured by daily gains and feed required per unit of gain, but differences between the higher levels

were not significant. The dry-fed pigs showed similar differences as the gruel-fed pigs in their response to protein levels in spite of a lower daily feed intake and rate of gain. Dry-fed pigs consumed approximately 1.0 pound less feed daily than the gruel-fed pigs, although it should be noted that the gruel-fed pigs were somewhat heavier initially.

Discussion. According to the tests reported herein, the pig from 1 to 4 weeks of age requires 22 percent protein in the diet as supplied by dried skim milk. Sewell *et al.* (1953a) using casein and an isolated soybean protein plus methionine noted that 20 percent protein gave slow growth in the pig from 2 to 30 days of age. In addition, Reber *et al.* (1953) with casein as the sole source of protein reported that a diet containing 41 percent protein yielded maximum performance in the pig from 12 to 24 days of age. In both cases, it is important to note that proteins probably of lower quality than dried skim milk were employed.

One of the striking findings here was the marked decrease in protein required during the normal suckling stage. The pig from 5 to 9 weeks of age required only 12 percent protein. Again with the supposedly lower quality protein, Reber *et al.* (1953) reported that the pig approaching 8 weeks of age appeared to need 20 percent protein.

It was interesting to observe that the depressed feed intake produced by dry feeding failed to influence the determination of the minimum protein requirement. That the protein requirement of the rat was not a function of the rate of feed intake or rate of performance was reported by Mitchell and Beadles (1952). Such a principle apparently applies to the determination of the protein requirement of the pig.

Mitchell and Carman (1926) have reported a biological value of 85 for dried skim milk protein as compared to 94 for whole egg protein. Since the milk proteins are of rather high biological value, it was thought that a knowledge of the amino acid composition would permit a calculation of the approximate amino acid requirements of the pig. Essentially the same method has been used by Harte and Travers (1947) and Mitchell (1950) to estimate the amino acid requirements of the adult man. In particular, such estimates of amino acid requirements are not influenced by questionable usage of D-isomers in racemic mixtures frequently employed in amino acid studies.

Based upon adequate levels of protein determined by the studies reported herein, the amino acid intakes were calculated and they are presented in table 5. Since Fairbanks and Mitchell (1935) have reported that the proteins of milk are deficient in the sulfur-bearing

amino acids, the estimated requirement for methionine plus cystine is less vulnerable than the estimates for the other amino acids. However, for the remaining amino acids, the estimated requirements should be rather accurate as the biological value of whole milk proteins is high, and the validity of the estimates may be expected to be proportional

TABLE 5. AMINO ACID INTAKE AT OPTIMUM LEVELS OF DIETARY PROTEIN IN THE YOUNG PIG

	Amino Acid Intake			
	1–4 Weeks of Age 22% Protein		5–9 Weeks of Age 12% Protein	
Amino Acids [1]	% of Diet	% of Protein	% of Diet	% of Protein
Lysine	1.42	6.45	0.72	6.00
Methionine	0.58	2.64	0.32	2.67
Cystine [2]	0.25 } 0.83	1.14 } 3.78	0.14 } 0.46	1.17 } 3.84
Tryptophan	0.28	1.27	0.15	1.25
Isoleucine	1.27	5.77	0.74	6.17
Phenylalanine	0.95	4.32	0.53	4.42
Tyrosine [2]	1.17 } 2.12	5.32 } 9.64	0.64 } 1.17	5.33 } 9.75
Histidine	0.58	2.64	0.33	2.75
Threonine	1.10	5.00	0.61	5.08
Valine	1.55	7.05	0.87	7.25
Leucine	2.16	9.82	1.18	9.83
Arginine	0.60	2.73	0.40	3.33

[1] Determined by microbiological assays using the medium of Henderson and Snell (1948). Crystalline bovine plasma albumin was used as a check on the reliability of the assays.
[2] Figures obtained from Block and Bolling (1951).

to the biological value of the protein used. Hence, these figures are not to be construed as minimum amino acid requirements but merely estimated needs to support satisfactory performance. The data are presented to permit comparison with recent amino acid studies and to serve as a guide in future investigations.

The minimum requirement of the weanling pig for certain amino acids has been investigated. Shelton *et al.* (1951a) have reported that the pig requires 0.3 percent methionine in the presence of 0.3 percent cystine; however, at this level of methionine lower levels of cystine were not studied. In addition, Curtin *et al.* (1952) with a 22 percent protein ration have reported that the weanling pig needs 0.33 percent methionine in the presence of 0.37 percent cystine. The data presented here indicate that lower levels of cystine may be sufficient when 0.3 percent methionine is offered to the weanling pig. Brinegar *et al.* (1950a) have reported that the weanling pig requires 1.2 percent lysine in a

22 percent protein diet. Shelton and coworkers (1951b, 1951c) have concluded that the weanling pig requires 1.0 percent L-lysine and 0.2 percent DL-tryptophan for maximum rate of gain and efficiency of feed utilization. Satisfactory performance with the pig from 5 to 9 weeks of age was noted here when lower intakes of lysine and tryptophan were offered. Futhermore, since lysine and tryptophan are not the limiting amino acids of milk protein, it is likely that our estimates of the requirement are somewhat high.

It is noteworthy that our estimated requirement of the weanling pig for isoleucine is similar to the minimum requirement noted by Brinegar *et al.* (1950b). However, the estimated requirements for threonine and valine are considerably greater than the requirements established with weanling pigs by Mertz *et al.* (1952) and Jackson *et al.* (1953), respectively. Likewise, the estimated threonine requirement of the baby pig from 1 to 4 weeks of age is greater than the requirement noted by Sewell *et al.* (1953b).

The fact that threonine and valine were ingested in larger amounts than other workers have found essential may reflect a limitation of the technic employed here. However, the data presented definitely emphasize the need for further studies on the minimum requirement of the weanling pig for certain amino acids, particularly lysine and tryptophan.

Summary

Experiments were conducted to ascertain the level of protein required by the young pig at two different ages to support maximum body weight gain and efficiency of food utilization when dried skim milk provided the sole source of protein. When baby pigs were fed *ad libitum* from 3 to 28 days of age, a protein level of 10.2 percent yielded slow growth, low feed intake, and inefficient weight gains. However, performance improved gradually with increasing protein levels up to 22.4 percent. Further studies, where the equal feeding technic was used, showed that the pig from 1 to 4 weeks of age requires 22 percent milk protein in synthetic milk diets of the caloric density used in these tests.

For the growing pig from 5 to 9 weeks of age, equalized feeding studies showed that 12 percent milk protein is the minimum requirement for satisfactory performance. Similar results were obtained regardless of whether the pigs were dry-fed or gruel-fed the diet, although considerably greater feed intake and hence greater body weight gains

were observed when the pigs were gruel-fed. The results indicated that a moderately depressed feed intake and hence decreased rate of gain did not influence the determined protein requirement.

Estimated amino acid requirements to support maximum growth at optimal levels of dietary protein in the suckling pig and in the weanling pig are also presented. The data stress the need for further studies on the lysine and tryptophan requirements of the weanling pig.

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A MEAL MIXTURE SUITABLE AS THE ENTIRE RATION TO BE SELF-FED DRY TO PIGS WEANED AT TEN DAYS OF AGE

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MUCH interest has been evidenced in the plan of early weaning of pigs. Formulae have been developed for "synthetic milks" the use of which has enabled the successful raising of pigs weaned at 48 hours after birth. The rations have frequently included materials as lard, casein, lecithin, etc., and the program has called for the final diet to be fed in liquid form. Such feeding practice involves several features which, from the practical pig raising standpoint, limit its application.

The age at which the pigs are weaned is commonly believed to be a factor dictating the nature of their early diets. It has been assumed that young pigs can be "artificially" fed a liquid more easily than a dry diet. This, in our experience, appears to be less a physiological matter than one of how quickly the pig learns to eat (or drink) from a feeder. Perhaps they recognize a liquid as possible food more quickly than they do dry material. In our tests for example, we have found that they do not at first distinguish between a dry food mixture and sawdust used as bedding. They are as likely to eat the latter as the former when they first start looking for food. However, the feeding of the diet in liquid form introduces the problems of labor of preparation and of souring of the "milk" in the feeders. The latter particularly is troublesome during the early days when the pigs do not promptly clean up their feed.

A second and more serious objection to many of the preparations is the presence of added fats or oils. Under practical pig raising, the problem of keeping feeding equipment acceptably clean is much complicated where fat-containing feeds are involved. It is intensified where the diet is fed in liquid form.

It has seemed to us that any advantages of 48-hour weaning are much diluted by the attending management and feeding difficulties;

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and that if by postponing weaning a further week it became feasible to use at once a dry, self-fed ration, the disadvantages of the later weaning would be more than offset by the simpler feeding.

Housing is an important part of any such program. In particular, bed warmth is critical and at the ages involved may effect the early progress of the pigs as much as the nature of the diet itself. For example, we have found that the period between weaning and the time when the pig learns to eat from a feeder is lengthened appreciably and sometimes excessively where pen and bed temperatures are below optimum. In our experience, pigs that are cold spend their time huddled together trying to get warm rather than in searching for food.

It was to obtain answers to some of the questions raised in attempting to adapt the "pig hatchery" scheme to practical conditions, that studies were undertaken in 1950 at Macdonald College with pigs weaned at 10 days of age. Some of our results are reported herein.

Plan of Experiment

The experiment was conducted in three successive replicates of 8 litters each and the general plan of each replicate was to feed, from an age of 10 days to the normal weaning age of 56 days, a part of the pigs of a litter on one or another of eight feed mixtures.

All litters of eleven or more were reduced to 10 pigs within 12 hours of birth by the removal of the smallest and/or weakest pigs. As each litter reached an age of ten days, five pigs in replicate 1, and four pigs in subsequent replicates, were picked at random and transferred to a separate pen $3' \times 9'$ in size, fitted with a bedding area, a self-feeder and a water dispenser.

The bed heating arrangements differed between each of the three replicates reported in this paper. In replicate 1, which was conducted during the summer, no supplementary heating was employed and room temperatures ranged between 65° to 75° F with the cooler temperatures at night. In replicate 2 infra red lamps were suspended over two of the pen beds, and incandescent lamps in a third. Poultry hovers with ceiling heating units were installed in two other pens and radient-heated hover-covered concrete slabs formed the beds in the remaining three pens. Air temperatures were maintained above 75° but were somewhat variable. In replicate 3 all pigs were bedded on radiant-heated hover-covered concrete slabs and hover air temperature was maintained at about 80° F.

These differences in bedding arrangements were responsible for a large part of the differences found between replicates, though replicate was unavoidablly confounded with litter.

The feeders and water buckets used were the same in all pens, their design having been established in preliminary trials. Provision was made to change the height of feeders above the floor as the pigs grew in size in view of our finding that feed spillage could be eliminated almost completely if the feeders were kept at a height requiring the pigs to feed without lowering their snouts much below a horizontal position.

The rations were arranged in a $2\times2\times2$ factorial design to permit major comparisons and interactions between two protein levels, two fat levels and two antibiotics. The design of each replicate of the feeding comparisons is shown in the allotment plan following.

The makeup of the rations is shown in table 2, and the approximate nutrient content of these rations in table 3.

TABLE 1. ALLOTMENT PLAN

Antibiotic Supplement	Ration Comparisons			
	30% Protein		26% Protein	
	3% Fat	8% Fat	3% Fat	8% Fat
Terramycin	I [1]	II	III	IV [2]
Penicillin	V	VI	VII	VIII

[1] Diet numbers.
[2] No pigs in this lot for replicate 3 due to failure of one sow to farrow.

When litters were 10 days old the pigs chosen were placed in one of the prepared pens. Until they had learned to eat, no bedding was placed on the pen floors. Pig weights were recorded weekly in all replicates. Group feed and water records were made for the test periods in replicates 1 and 2, and weekly in replicate 3. The pigs from each litter which remained with their dams were also weighed weekly.

Results

Health of Pigs

The survival of the early weaned pigs as compared to their 56-day weaned litter mates is indicated in table 4.

The mortality record does not appear to be related to any diet factor or factors. The diarrhea in replicate 1 we believe was related

TABLE 2. MIXING FORMULAE FOR 100 LB. OF EACH OF THE EIGHT DIETS FED

Ingredients	Diets			
	I and III	II and IV	V and VII	VI and VIII
	lb.	lb.	lb.	lb.
Dried skimmilk	37–20	37–20	37–20	37–20
Cane molasses	10	10	10	10
Ground wheat	10–22	10–22	10–22	10–22
Ground oat groats	15–20	10–20	15–20	10–15
Soyabean oilmeal	10	10	10	10
Fishmeal	10	10	10	10
Brewers' dried yeast	5	5	5	5
Corn oil	..	5	..	5
	lb.		lb.	
Bone flour	2.28		2.20	
Salt (iodized)	.44		.42	
Ferrous sulphate	.14		.14	
T.M.5 (Pfizer) [1]	.14		...	
Penicillin (Merck) [2]	...		.24	
Supplementary additions				
Vitamin A	450,000 i.u.			
Vitamin D_3	100,000 i.u.			
Riboflavin	200 mg.			
Pyridoxine	200 mg.			
Ca-pantothenate	400 mg.			

[1] Contains 5 gm. terramycin per lb. concentrate.
[2] Contains 2 gm. procaine penicillin per lb. concentrate.

TABLE 3. APPROXIMATE NUTRIENT CONTENT OF DIETS FED

Nutrient		Diets			
		I and V	II and VI	III and VII	IV and VIII
Crude protein	%	30	30	26	26
Ether extract	%	3	8	3	8
Crude fibre	%	1.5	1.5	1.9	1.9
N-free extract	%	48	44	50	47
Ash	%	7	7	7	7
Calcium	%	1.6		1.4	
Phosphorus	%	1.1		1.1	
Thiamine	mg. per lb.	3.3		3.3	
Riboflavin	"	7.2		5.7	
Niacin	"	25.0		25.0	
Pantothenic acid	"	16.0		16.0	

to unsuitable bed temperatures. Observation of the test pigs and their litter mates that were left on their dams led to the general conclusion that differences in mortality and thrift were more related to breeding than to diet. The most uniform and most thrifty 10-day weaned groups came from litters where the suckling pigs were also uniform and thrifty.

TABLE 4. MORTALITY OF PIGS BETWEEN THE AGES OF 10 AND 56 DAYS
(10-Day Weaned Versus 56-Day Weaned)

Comparison		Lots							
		I	II	III	IV	V	VI	VII	VIII
1st Repl.	Suckled							1	
	10-day weaned				1	[a]	1[a]	1[a]	2[a]
2nd Repl.	Suckled		2						
	10-day weaned		1						
3rd Repl.	Suckled					1			
	10-day weaned								1
All tests	Suckled (100 pigs)	0	2	0	0	1	0	1	0
	10-day-weaned (96 pigs)	0	1	0	0	0	1	1	3

[a] Diarrhea

Response to rations

The overall response of the pigs to the rations and feeding practice for the 46-day period may be summarized as follows:

Daily gain per pig	0.50 lb.
Daily feed per pig	0.87
Gain per 100 lb. feed	57.00
Daily water per pig	3.80

The average final weight of all pigs under all regimens was 29 pounds. If the data for replicate 1, which was markedly poorer than that for later replicates due largely to unsatisfactory bed heating arrangements, are delated, the average final weight of the pigs was 31.6 lb. and the average daily gain 0.56 lb. The average 56-day weaning weight of the sow-nursed litter mates in these trials was 25 pounds.

In connection with this latter figure, it should be stated that there were several litters in which but two or three pigs remained with the sow, and the sows of such litters tended to go dry. Consequently, the weights of the early weaned pigs may be compared better to a figure of 30 lb. as the average 56-day weaning weight of sow-nursed pigs from this same herd over a period of some 20 years.

The Quebec Provincial Feed Board Bulletin gives the expected weight of a sow-nursed pig at 8 weeks of age as 30 lb., and expected daily gains at that age of 0.5 lb. per day. These average figures are of interest only to indicate that the performance of the 93 early weaned pigs was comparable to present standards for Canadian Yorkshire sow-nursed pigs.

The results of the several imposed experimental conditions are shown in table 5.

Replicates

As noted in the statement of experimental design, the replicates differed chiefly in the arrangements for supplying warm bed areas. There was a significant improvement in the performance of the pigs in the last two replicates which we believe is traceable to higher and more uniform bed temperatures, as compared to replicate 1. Supplementary barn tests bear out the need for warm, dry beds for pigs of this age. Air temperatures of 80° F were needed to prevent piling up of the pigs in the warmest spots in their beds, (the criterion we took to indicate adequate warmth).

Antibiotics

As shown in table 4, some diarrhea was found in each of the four lots receiving penicillin during replicate 2 which might well have been caused from the unsatisfactory arrangements for bed warmth. It may be significant that no scours was seen among pigs receiving terramycin.

Insofar as progress of the pigs was concerned, it is evident from table 5 that the penicillin-fed lots gained about 18% faster than those on terramycin. This was statistically significant. The greater gains were largely a reflection of 14% greater voluntary feed intake, and to a lesser degree an increase in feed efficiency, both of which were statistically just significant and in favor of penicillin.

Protein Level

Our findings indicate that 26% protein of the sort provided in this test is below optimum for pigs of this age. Raising the protein to 30% resulted in a statistically significant increase of 28% in gain. There was some increase (12%) in feed eaten, but of greater practical

TABLE 5. SUMMARY OF FINAL WEIGHTS, DAILY GAINS, FEED INTAKE AND FEED EFFICIENCY OF PIGS WEANED AT 10 DAYS OF AGE AND SUBSEQUENTLY SELF-FED A DRY MEAL RATION TO AN AGE OF 56 DAYS

Groups	No. Pigs	56-Day Weight	Daily Gain	Daily Feed	Gain Adjusted to Av. Feed
		(kg.)	(gm.)	(gm.)	(gm.)
Replicate					
1	35	10.4	186	287	241
2	31	15.0	267(43)*	469(68)	232(28)
3	27	13.7	241	443	214
Antibiotic					
Terramycin		12.4	210 (33)	370 (55)	224 (11)
Penicillin		13.9	248	424	235
Protein					
30%		14.3	255 (33)	421 (55)	243 (11)
26%		11.7	198	374	210
Fat					
8%		14.0	246 (33)	405 (55)	242 (11)
3%		12.4	215	391	219
Test Averages					
All replicates	93	13.2	229	397	229
Repl. 2 and 3 only	58	14.3	259	456	223

* ( ) approximate least significant difference between means with P of .05.

importance was the 15% increase in feed efficiency. The pigs drank about 40% more water per unit of feed eaten as a result of the higher protein level.

Fat Level

The addition of 5% corn oil to the ration (which already carried 3% ether extract) resulted in some increase in gain but had no appreciable effect on feed intake. Consequently, feed efficiency was increased considerably (18%), which can be explained largely by the

higher caloric value of the corn oil rations. The difference in efficiency on a calorie basis between the two fat levels was only about a third of that calculated on the basis of weight of feed eaten.

Discussion

The primary objective of this project was to devise a low-fat, dry feed mixture on which pigs, weaned at 10 days of age could, under a self-feeding program, be raised satisfactorily to the "normal" weaning age of about 56 days.

In this study we assumed that an antibiotic was desirable, and our results indicate that between terramycin and penicillin the latter may be associated with more rapid gains as a consequence of greater feed consumption, and perhaps a small increase in feed efficiency.

Thirty percent protein is preferable to 26%. This higher protein ration, without added fat, produced a 33 lb. pig in 56 days. Average daily gain was 0.63 lb. with a feed intake of 1.1 pounds. These results are above those considered "normal" for comparable sow-nursed pigs.

The question of desirable fat level is a somewhat different matter. The addition of 5% corn oil resulted in greater gains and, as would be expected from its higher calorie values, an improved gain per unit of feed eaten. Other tests now in progress in our laboratory have demonstrated that by the addition of 10% of certain oils to this 30% ration, gains during the 46-day period of the order of .8 lb. per day at a feed efficiency of 66 lb. gain per 100 lb. of diet, can be attained. However, at this fat level (13%) the feed is noticeably oily and feeding equipment cannot be kept clean without special treatment.

Summary

The tests herein reported demonstrate that it is feasible to prepare a feed mixture, without added fat or oil, which when self-fed dry to pigs weaned at 10 days of age will permit growth and development fully equal to that usually attained by sow-nursed pigs of comparable breeding.

EFFECTS OF SUBSTITUTING XYLOSE FOR GLUCOSE IN A PURIFIED DIET FOR PIGS[1]

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XYLOSE is one of the major constituents of wood molasses, which is considered as a potential feed for various classes of livestock. Though ruminants seemingly are able to utilize this product satisfactorily (Blosser *et al.*, 1951; Colovos *et al.*, 1949; and Waugh *et al.*, 1954), swine apparently are not (Harris, 1948). It has been postulated that the presence of pentoses may be a major factor affecting the feed value of wood molasses for monogastric animals adversely.

In the rat most of the ingested xylose is absorbed from the intestine (Blatherwick *et al.*, 1936; Cori, 1925; and Miller and Lewis, 1932) resulting in increased blood sugar levels (Blatherwick *et al.*, 1936; Darby and Day, 1940; and Sterling and Day, 1951) but no increase in liver glycogen (Anderson, 1950; Blatherwick *et al.*, 1936; and Miller and Lewis, 1932). In the rabbit also, xylose administration effected an increase in the blood sugar level (Blanco, 1928). Anderson (1950), Chasis *et al.* (1933), Corley (1926), and Dominquez *et al.* (1934) noted that a high percentage of xylose administered to animals is excreted via the urinary pathway.

Cataract formation (Booth *et al.*, 1953; Darby and Day, 1940; and Sterling and Day, 1951), decreased voluntary activity, depressed appetite, diarrhea and bloat (Anderson, 1950) were observed in rats fed diets containing a high percentage of xylose.

Since little information is available on the nutritive value of pentoses for swine, work was designed to ascertain responses of young growing pigs to diets containing xylose.

Experimental

Two experiments were conducted with young pigs. Experiment I was a growth-performance study designed to compare (A) glucose,

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[3] The authors express their appreciation to the Northern Regional Research Laboratory of the United States Department of Agriculture for the liberal quantities of xylose supplied through the courtesy of Dr. E. C. Lathrop.

[4] Raleigh.

(B) a 50–50 mixture of sugars and (C) xylose as carbohydrate constituents in purified diets that were hand fed. Experiment II was not only a growth-performance study but also a metabolic investigation, including nitrogen retention and urinary sugar excretion, of pigs pair-fed diets containing either (D) glucose or (E) xylose.

In both experiments the solids (table 1) were diluted to a concentration of 15%. Sufficient quantities to last 2 weeks were mixed,

TABLE 1. SOLID COMPONENTS OF "PURIFIED" DIETS

Constituent of Diet	Expt. I			Expt. II	
	A	B	C	D	E
	%	%	%	%	%
Casein	30.0	30.0	30.0	30.0	30.0
Glucose	37.4	18.7	....	56.0	....
Xylose	....	18.7	37.4	....	56.0
Lard	26.6	26.6	26.6	8.0	8.0
Mineral salts [1]	6.0	6.0	6.0	6.0	6.0

[1] Modified salt mixture of Phillips and Hart (1935).

pasteurized, homogenized and subsequently stored at a temperature of 32° F. Vitamin supplements and methods of incorporation were as outlined by Lehrer *et al.* (1949).

Experiment I

Procedures

Twelve 2-week old pigs were selected from 3 litters of the same age and similar breeding. Four replications of 3 pigs each were chosen on the basis of similarity in weight and were randomly assigned to individual cage units having wire bottoms.

The three diets, A, B, and C, (table 1) were fed from open glass dishes. A transition period of 7 days was allowed for the pigs to adjust to their respective diets after which time the pigs were fed all they would consume in three 45-minute periods daily, morning, noon and evening.

Weights of pigs were determined at weekly intervals throughout a 38-day test period. Frequent inspections were made for gross effects of the treatments. At the end of the experiment, one pig, selected at random, from each dietary group was sacrificed for autopsy.

Results

The inclusion of xylose in the diet resulted in decreased feed consumption (table 2). This depression of appetite apparently was physiological since several palatability factors, odor, flavor and general physical condition, of all three diets were similar. The fact that the

TABLE 2. AVERAGE FEED CONSUMPTION AND WEIGHT GAINS OF PIGS FED GLUCOSE, XYLOSE, OR A MIXTURE OF THE TWO

Criteria	Responses to Diets		
	A (Glucose)	B (Mixture)	C (Xylose)
	lb.	lb.	lb.
Weekly gain per pig	3.48	1.34	0.76
Weekly feed consumption (solids)	4.89	3.54	2.94
Feed per pound gain	1.41	2.64	3.86

average quantities of consumed feed ranged from 4.89 lb. per pig for diet A to 3.54 lb. for diet B and 2.94 lb. for diet C leads to the belief that the depression of appetite was due to either a deficiency or an imbalance in the ration or to some toxic reaction from the xylose in the diet. During the 2-week transition period at the beginning of the experiment, vomiting and diarrhea of short duration were observed in pigs fed diets B and C (containing xylose), whereas no digestive disturbances were encountered among pigs receiving diet A (glucose). Throughout this experiment, the voluntary activity of pigs receiving xylose was markedly less than that of pigs receiving glucose.

The growth curve for pigs receiving diet A approximated closely the normal reported by Ittner and Hughes (1942), whereas the growth curves for pigs fed diets B and C were subnormal. Average gains for the pigs fed glucose only were over four times those for pigs fed xylose only and over twice those for pigs receiving the 50–50 mixture of the sugars (table 2).

Application of the analysis of variance technique (table 3) to gains of individual pigs revealed that these differences in responses to diets were highly significant.

Near the termination of the experiment, the hair coats of pigs receiving diets B and C became rough and dry; while the hair of the pigs on diet A remained sleek and smooth. Post-mortem examination revealed no gross abnormalities in any of the pigs.

Experiment II

Procedure

Five pairs of 2-week old pigs were selected from 3 litters born within a period of 48 hours. All pair mates were from the same litter and were as nearly the same size as selection within litters permitted.

TABLE 3. ANALYSIS OF VARIANCE OF GAINS MADE BY PIGS FED GLUCOSE, XYLOSE, OR A COMBINATION OF THE TWO AS SOURCES OF CARBOHYDRATE

Sources of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	"F" Value
Total	59	112.40		
Treatments	2	79.91	39.975	68.69**
Replications	3	1.42	0.473	.813
T × R (Error A)	6	3.49	0.582	1.504
Weeks	4	8.43	2.017	5.986**
T × W	8	6.48	0.810	2.301*
R × W	12	3.38	0.282	.729
T × R × W	24	9.29	0.387	
Pooled Error (B)	36	12.67	0.352	

* Significant (P less than .05)
** Highly significant (P less than .01)

To facilitate collection of excreta for the balance studies, only males were used. Pigs were enclosed in wire bottom cages elevated on wood frames. During the balance study, the pigs were confined to a small area of the cage to facilitate urine collection and to attempt to equalize voluntary activity. A large glass funnel was fitted into a flask and placed directly beneath each animal. Glass wool was placed into the neck of the funnel to prevent contamination of the urine.

Diets D and E (table 1), differing only in the source of carbohydrate, were fed throughout the 14-day preliminary period and the 35-day test period. The amount of feed offered the individuals of each pair was determined by the quantity that the pig eating the smaller amount would consume. All pigs were fed 4 times daily from an open dish.

Feces and urine were collected once daily for 7 consecutive days during the second week of the test period. The total output of feces was sprayed with ethyl alcohol, dried in an electric oven and composited. A 10% sample of the urine was composited daily and subsequently stored at a temperature of 32° F. Sulfuric acid and toluene were added to both the collection and the composite flasks to preserve

the urine. At the end of the collection period, the nitrogen content of samples of feed, urine and feces was determined by the standard Kjeldahl procedure (A.O.A.C., 1945). Inasmuch as Corley (1926) found that 98–103% of the urinary sugar of rabbits receiving xylose was unfermentable by yeast, Benedict's reagent (Hawk *et al.*, 1951) was used to determine total sugars in the urine of the test animals. A second balance trial was attempted during the terminal week of the experiment, but an outbreak of diarrhea in the pigs receiving xylose prevented completion.

Weight gains were determined weekly. When the feeding experiment was concluded, one pair of pigs and one additional xylose-fed pig were sacrificed for autopsy.

TABLE 4. AVERAGE FEED CONSUMPTION AND WEIGHT GAINS OF PIGS FED GLUCOSE OR XYLOSE AS SOURCES OF CARBOHYDRATE

Criteria	Responses to Diets	
	D (Glucose)	E (Xylose)
	lb.	lb.
Weekly gain per pig	1.63	0.95
Weekly feed consumption (solids)	2.43	2.43
Feed per pound gain	1.48	2.53

Results

Vomiting and diarrhea, which continued from the second to the eighth day, were noted among pigs fed diet E. During this time, these pigs consumed only a small amount of feed and appeared unthrifty. Their pair mates receiving diet D remained vigorous and apparently healthy. After 7 days, 1 pig fed diet E died, but the other 4 gradually increased their feed intake and survived throughout the trial. Low feed consumption, however, persisted during the entire experiment (table 4).

Statistical analysis of total weight gains (table 5) during the 5-week experimental period revealed a highly significant difference due to dietary treatment. Even though feed consumption was the same for both diets, the pigs fed the glucose gained almost twice as much as those receiving the xylose diet (table 4).

Data presented in table 6 revealed that for pigs fed diet D (glucose) nitrogen retention was significantly greater (P less than .01) and urinary sugar excretion strikingly less than found for pigs fed diet E (xylose).

TABLE 5. PAIRED COMPARISONS OF WEIGHT GAINS OF PIGS FED GLUCOSE OR XYLOSE AS SOURCES OF CARBOHYDRATE

Pair	Total Weight Gains		
	Diet D (Glucose)	Diet E (Xylose)	Difference
	lb.	lb.	lb.
1	4.5	1.6	2.9
2	8.4	5.5	2.9
4	10.0	5.4	4.6
5	9.7	6.2	3.2
Total	32.6	19.0	13.6
Mean	8.15	4.75	** 3.40±.406
t=8.368**			
L.S.D.=2.373			

** Highly significant (P less than 0.01)

Further evidence supporting the foregoing results was obtained from an absorption study conducted with a replication of 3 day-old pigs in a post-absorptive state. The respective pigs received a glucose solution, a xylose solution and distilled water. Blood samples were drawn before the administration of the solution and thereafter at intervals of 30 minutes during the first hour and of 60 minutes during the subsequent 4 hours. The observed blood sugar levels indicated that the xylose absorption reached a peak in approximately 30 minutes and subsequently underwent a gradual decline, whereas the glucose reached its peak at 2 hours followed by a more rapid decrease. After 5 hours, the blood sugar level for the pig administered glucose had declined to a normal value; while the level for the pig receiving xylose

TABLE 6. NITROGEN RETENTION OF AND SUGAR RECOVERY FROM PIGS FED GLUCOSE OR XYLOSE AS SOURCES OF CARBOHYDRATE

Pair	Nitrogen Rentention		Sugar Recovery [1]	
	Diet D (Glucose)	Diet E (Xylose)	Diet D (Glucose)	Diet E (Xylose)
	gm.	gm.	%	%
1	11.77	2.96	0.74	63.06
2	21.54	8.34	0.53	33.34
4	24.78	8.11	0.58	65.11
5	20.08	10.10	0.71	37.36
Mean	19.54	7.38	0.64	49.72

[1] Each value is an average for two 7-day periods.

was still abnormally high. The blood sugar level of the control pig (given distilled water) dropped slightly during this 5-hour period.

As in Experiment I, the pigs fed xylose were less active and the hair coat rougher than noted in pigs receiving glucose. Furthermore, the color of the hair of xylose-fed pigs changed from a deep red to a yellowish-red.

After approximately 4 weeks on experiment, a bluish-white opacity, which was diagnosed as cataract both by gross clinical observation and by histological study,[5] developed in the lenses of the eyes (figure 1)

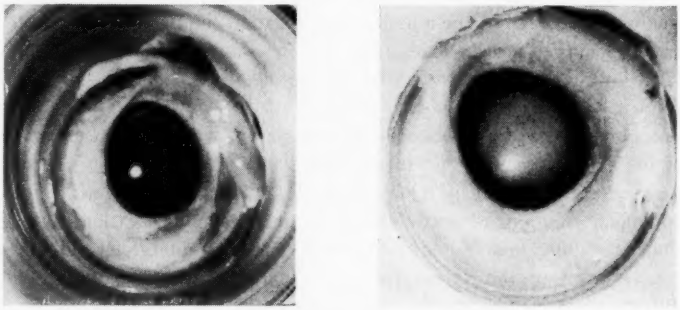

Figure 1. Representative normal eye from a pig fed glucose (left); representative cataract eye from a pig fed xylose (right).

of all pigs receiving diet E (xylose). When the experiment was terminated, 3 pigs were totally blind and another was almost blind. Feeding of a well balanced herd-type ration for three months after discontinuing the xylose diet did not improve the eye condition.

Histopathological study of the kidneys of the pigs fed diet E showed mild glomerulo nephritis. Hemorrhage in some areas of the Loops of Henle and cloudy swelling throughout the parenchyma were noted. No abnormal changes were detected in pigs fed diet D.

Discussion

The growth of pigs receiving the diet containing the mixture of xylose and glucose (Expt. I) might be expected to be about mid-way between observed responses from diets containing the respective sugars. Responses to the mixture, however, were closer to those from the xylose diet than to those from the glucose diet. One explanation for

[5] The authors are indebted to the Armed Forces Institute of Pathology for their histological study of the eye tissue.

this is that both groups of pigs receiving xylose consumed less feed due to depression of appetite. This symptom was similar to that observed in xylose-fed white rats, (Anderson 1950). The significant differences in gain between diets, even after intake was eliminated as a factor, indicate that xylose has relatively little value as a source of energy for growing pigs. This is supported further by the low nitrogen retention of pigs receiving xylose.

In Experiment II, two of the pigs fed the diet containing xylose consistently made greater gains than the others on the same diet. These more rapidly gaining pigs retained more nitrogen, excreted a smaller percentage of the administered sugar in the urine and exhibited less pronounced eye changes than did the slower gaining pigs. These facts indicate individual variation in the metabolism of xylose. Davidson and Gary (1939) reported a significant loss of xylose from a solution incubated with rat feces. This loss apparently was due to conversion of the xylose to simpler substances. Gest and Lampen (1952) observed that xylose fermented by resting cells of *Lactobacillus pentosus* yielded equimolar solutions of acetic and lactic acid. This observation suggests that the differences noted in growth, nitrogen retention and sugar recovery within the xylose fed group may be ascribed, in part, to differences in metabolites resulting from a difference in intestinal flora.

Booth *et al.* (1953) produced cataracts on the eyes of weanling rats by feeding xylose at a level of 15% of the diet; however, the lenses regained much of their lost transparency as the experiment progressed. These workers pointed out that their findings were in line with the speculation that the basic cause of lens opacities is a non-specific osmotic derangement (Bellows and Chinn, 1941), either local or systemic. The extent to which the concentrations of xylose in the body of the pigs in this study might have altered the osmotic pressure is conjectural, but conceivably this phenomenon could have been a factor. It should be pointed out, however, that in contrast to observations on rats, the lens damage appeared to be irreversible in this experiment.

Summary

Two experiments were conducted to compare xylose and glucose as sources of carbohydrate in the diets of young pigs.

Experiment I consisted of a growth-performance study using 4 replications of pigs, which were hand fed three purified diets containing 37.4% of sugar, glucose, xylose, or a 50–50 mixture of the two. Experiment II included studies of nitrogen retention and sugar recovery

as well as of growth-performance; data were obtained from 5 pairs of pigs, which were pair-fed comparative diets containing 56%, respectively, of glucose or of xylose.

Growth-performance and balance studies indicated that pigs were able to utilize glucose to a greater degree than xylose.

Cataract formation resulted after feeding a diet containing xylose at the level of 56% of the dry matter.

Voluntary activity was decreased, and the color of the hair coat was altered from deep red to yellowish-red in pigs fed xylose.

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THE EFFECT OF RATIONS ON SELECTED VITAMIN CONTENT OF SOWS' MILK [1]

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ROUTINE chemical analyses (protein, fat, calcium, phosphorus, solids and moisture) of sows' milk have been reported by many workers. Hughes and Hart (1935), Bowland *et al.* (1949a), and Smith (1952) have reviewed the work of these investigators. Braude *et al.* (1946), Thomas *et al.* (1946), Luecke (1947), Bowland *et al.* (1949b, 1949c), Collins *et al.* (1951), Heidebrecht *et al.* (1951), and Davis *et al.* (1951) have all contributed information regarding the vitamin content of sows' milk.

The research reported in this paper was undertaken to determine the effect of gestation and lactation rations on the riboflavin, niacin and pantothenic acid content of sows' milk, and to attempt to correlate the vitamin composition of the sows' milk with the nursing pig performance.

Experimental Procedure

Twelve Duroc sows from two gestation-lactation feeding experiments, numbers 438 and 443, were selected at random for this study. The sows were milked on the second, seventh, twenty-first, and fifty-sixth days of lactation. Four sows were also milked on the fifty-fourth and fifty-sixth days of lactation to obtain milk samples from individual glands.

Sows and their litters were separated six hours prior to milking. The sows were placed in a holding crate and were given an intravenous injection of either three ml. of posterior pituitrin or two ml. of pitocin, the oxytocic hormone of the posterior pituitary. They were milked by hand as quickly as possible following injection of the hormone. The transitory influence of either the pituitrin or pitocin averaged about 10 minutes. The intravenous injection of posterior pituitrin has been a technique long employed by dairymen for the quick and complete removal of preformed milk from mammary glands (Espe,

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1946). One-half pint, heavy paper, paraffin-coated cups proved to be most satisfactory for collection and storage of milk samples. Samples were sealed, quick-frozen, and held in deep freeze until assay determinations were made.

Riboflavin was determined by a modification of the method of Snell and Strong (1939). Pantothenic acid and niacin were determined by a modification of the method of Krehl and Strong (1943).

TABLE 1. EXPERIMENT 438. RATIONS FED DURING GESTATION AND LACTATION

Ingredients	Plant Protein		Plant & Animal Protein	
	Ration #1 Basal	Ration #2 Basal Plus 10% Alfalfa Meal	Ration #3 Basal	Ration #4 Basal Plus 10% Alfalfa Meal
Yellow corn	77.0	70.0	82.5	75.5
Soybean oil meal	16.5	14.5	3.0	....
Tankage (60%)	....	....	10.0	10.0
Dehydrated alfalfa meal	....	10.0	....	10.0
Mineral mix No. 3 [1]	2.5	2.5	1.5	1.5
Vitamin A and D premix	4.0	3.0	4.0	3.0
Calculated Analysis				
Protein, %	16.0	16.0	16.0	16.0
Fat, %	3.2	4.1	3.9	3.8
Fiber, %	3.2	4.8	2.7	4.3
Calcium, %	0.66	0.79	1.0	1.16
Phosphorus, %	0.47	0.45	0.65	0.62
Vitamin D_2, USP units per lb.	200.0	150.0	200.0	150.0
Vitamin A, IU per lb.	4748.0	19086.0	4873.0	19210.0
Riboflavin, mg. per lb.	0.84	2.34	0.73	2.23
Niacin, mg. per lb.	8.54	7.56	8.95	8.06
Pantothenic acid, mg. per lb.	6.14	5.39	3.55	4.80

[1] Mineral mix No. 3—ground limestone, steamed bonemeal, salt plus trace minerals, iron, manganese, cobalt, zinc, iodine and magnesium.

Results

Experiment 438

Eight sows, two on each ration treatment, were selected from this experiment. The composition of the four different rations is given in table 1. All milk samples were assayed for riboflavin, pantothenic acid, and niacin to study the effect of rations on the composition of milk produced by the sows. Assay data for niacin, riboflavin and pantothenic acid are presented in table 2.

TABLE 2. EXPERIMENT 438. SUMMARY OF VITAMIN CONTENT OF SOWS' MILK (MCG/ML)

Day of Lactation	Riboflavin					Pantothenic Acid					Niacin				
	A	B	C	D	Ave.	A	B	C	D	Ave.	A	B	C	D	Ave.
2	2.55[1]	2.80	2.70	2.15	2.55	1.75	4.65	1.60	2.82	2.71	4.70	8.80	3.55	10.90	6.99
7	1.40	2.20	1.45	2.30	1.84	2.45	4.85	2.20	4.00	3.38	2.50	8.80	3.10	2.20	4.15
21	1.12	2.00	1.08	1.60	1.45	4.10	5.85	3.00	5.55	4.63	4.50	7.20	6.70	5.50	5.98
56	1.35	2.28	1.45	2.20	1.82	4.70	6.70	2.65	5.90	4.99	7.15	8.90	7.75	7.65	7.86
Ave.	1.60	2.32	1.67	2.06		3.25	5.51	2.36	4.57		4.71	8.42	5.28	6.56	
S.D.[2]			3.42					0.465					0.678		

A=plant basal
B=plant basal plus 10 percent alfalfa meal.
C=plant and animal basal.
D=plant and animal basal plus 10 percent alfalfa meal.
[1] Average of values from 2 sows.
[2] Standard deviation of a single observation.

TABLE 3. SUMMARY OF VITAMIN CONTENT OF SOWS' MILK FROM INDIVIDUAL MAMMARY GLANDS (MCG/ML)
(Composite of 54th and 56th day samples from 4 sows)

Teat No.	1	2	3	4	5	6	7	8	9	10
Riboflavin	1.8	1.7	1.6	2.1	1.6	1.7	1.6	1.7	1.6	2.1
Niacin	7.8	7.6	7.4	6.8	9.2	8.5	6.3	9.0	8.0	7.3
Pantothenic acid	4.7	4.0	3.3	4.4	3.2	4.1	3.3	4.5	3.5	4.5

Separate samples were collected from each gland from each of the four sows on the fifty-fourth and fifty-sixth days of lactation. These samples were assayed to determine if there were any differences in the vitamin content of the milk from different glands of the same sow. No significant differences were noted as indicated in table 3.

The addition of 10 percent dehydrated alfalfa meal to the plant or animal protein basal ration increased the pantothenic acid content of the milk significantly. No statistically significant differences were found in the niacin and riboflavin content of the milk samples from the sows on the different ration treatments.

A summary of the number of pigs farrowed and weaned by these eight sows may be noted in table 4.

TABLE 4. PERFORMANCE SUMMARY OF SOWS MILKED

Lactation Treatment	No. of Sows Milked	Av. No. Pigs Farrowed per Litter	Av. No. Pigs Weaned per Litter	Av. Wt. Pigs at 56 Days
	Experiment 438. Spring 1947			
Plant protein basal	2	9.5	7.0[1]	22.6
Plant protein basal plus 10% alfalfa	2	9.5	5.5[1]	19.4
Plant plus animal protein basal	2	9.5	6.5[1]	25.1
Plant plus animal protein basal plus 10% alfalfa	2	10.0	7.5[1]	19.0
	Experiment 443. Spring 1948			
Basal ration	2	10.0	9.5	31.9
Fortified ration	2	7.5	7.0	26.4

[1] One pig was sacrificed from each sow before weaning for another phase of this experiment.

Experiment 443

Four sows were selected at random from this gestation-lactation experiment and were milked in the same manner as previously described. Rations fed these sows are given in table 5. Routine chemical analyses

TABLE 5. EXPERIMENT 443. RATIONS FED DURING GESTATION AND LACTATION [1]

Ingredients	Basal Supplement	Fortified Supplement: Basal Supplement Plus Meat Scraps and Dehy. Alfalfa Meal
42% exp. soybean oil meal	73.47%	14.81%
50% meat scraps	.....	37.05%
17% dehy. alfalfa meal	.....	37.05%
Vitamin A premix [2]	8.16%	.....
Vitamin D_2, premix [3]	8.16%	7.41%
Mineral mix No. 3 [4]	10.21%	3.70%
Calculated Analysis		
Protein, %	36.95	34.57
Fat, %	3.15	4.67
Fiber, %	5.38	12.26
Calcium, %	2.72	5.23
Phosphorus, %	0.94	2.19
Manganese, ppm.	199.00	72.00
Vitamin A, IU per lb.	17136	48152
Vitamin D_2, USP units per lb.	816	741
Riboflavin, mg. per lb.	1.35	3.89
Niacin, mg. per lb.	15.71	20.56
Pantothenic acid, mg. per lb.	5.39	8.37
Choline, mg. per lb.	1167.00	918.00

[1] Supplements fed with shelled corn (No. 2 yellow) in proportion of 1:3 to provide approximately a 16% protein ration.

[2] Vitamin A premix—2 lbs. expeller soybean oil meal and 35 gm. of a 12,000 IU/gm. vitamin A oil.

[3] Vitamin D_2 premix—2 lbs. expeller soybean oil meal and 2.27 gm. of a 4 million USP units/lb. vitamin D_2 concentrate.

[4] Refer to table 1 for mineral mix No. 3 formula.

were made on the samples as well as vitamin assays for riboflavin, pantothenic acid, and niacin. These data are summarized and presented in table 6. The number of pigs farrowed and raised by these sows is reported in table 4. Although fortification of the basal ration increased the quantity of both niacin and riboflavin, only the latter was significantly increased.

Summary

Either three ml. of posterior pituitrin or two ml. of pitocin proved

TABLE 6. EXPERIMENT 443. COMPOSITION OF SOWS' MILK

Day of Lactation	Ration	Riboflavin	Pantothenic Acid	Niacin	Protein	Fat	Calcium	Phosphorus	Solids	Moisture
		(mcg./ml.)	(mcg./ml.)	(mcg./ml.)	%	%	%	%	%	%
2	Basal	1.65[1]	2.20	2.50	6.49	6.95	0.180	0.154	19.1	80.9
	Fortified	2.25	1.70	4.15	6.98	7.35	0.207	0.170	19.9	80.1
7	Basal	1.20	2.60	4.05	6.05	5.35	0.234	0.153	18.2	81.8
	Fortified	1.38	2.50	5.60	6.63	4.85	0.203	0.200	18.8	81.2
14	Basal	0.85	2.00	5.75	6.13	4.30	0.399	0.193	20.9	79.1
	Fortified	1.05	1.90	3.80	5.54	5.90	0.232	0.143	16.9	83.1
21	Basal	0.64	2.80	5.70	5.99	3.75	0.287	0.188	17.5	82.6
	Fortified	1.15	2.45	5.15	7.62	7.75	0.391	0.257	22.2	77.8
56	Basal	1.35	4.55	4.70	8.82	7.10	0.519	0.241	21.5	78.5
	Fortified	1.80	3.60	6.35	6.52	6.00	0.312	0.175	18.2	81.8
Ave.	Basal	1.14	2.83	4.54	6.69	5.49	0.324	0.186	19.4	80.6
	Fortified	1.53**	2.43	5.10	6.66	6.37	0.269	0.189	19.2	80.8
S.D.[2]		0.496	1.05	1.65	1.21	1.61	0.132	0.046	2.87	2.87

[1] Average of values from 2 sows.
[2] Standard deviation of a single observation.
** Increased riboflavin content, probability of 0.01.

satisfactory in obtaining milk from sows without any apparent harmful effects to the sow.

Riboflavin, niacin and pantothenic acid content of sows' milk was increased when ten percent dehydrated alfalfa meal was added to a basal ration of corn, soybean oil meal, tankage, and minerals in the first experiment. However, only the pantothenic acid was significantly increased statistically. In another experiment, the addition of dehydrated alfalfa meal and meat and bone scraps to the basal ration increased the riboflavin content of the milk significantly. In the latter experiment, no significant differences were found in the pantothenic acid or niacin content of the milk. However, through lactation, the quantity of riboflavin and pantothenic acid in sows' milk in the latter experiment followed essentially the same pattern as in the former. Yet, the pattern for the niacin content of the sows' milk from the latter experiment failed to conform to that found in the former.

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INTERRELATIONSHIPS OF SWINE WEIGHTS AT THREE AGES [1]

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RAPID growth is desirable in swine because (1) rate of gain is related to efficiency of feed utilization, and (2) costs for certain items such as labor, interest on investment, and risk are reduced for pigs reaching market most quickly.

A knowledge of the relationships between the weights of pigs at young ages and what they will be later should be of value to investigators in predicting performance of various lines, breeds, or crosses under test. The magnitude of these relationships has much to do with evaluating the potential usefulness and the limitations of production testing programs using weaning weights as an endpoint. The selection of potential breeding stock early in life so that they can be raised according to methods which will lead to greatest potential reproductive efficiency may be practiced in the future if further work should confirm the data of Robertson *et al.* (1951). This work indicates that management and nutrition regimes necessary for greatest future reproductive efficiency vary with age.

Material and Methods

The data for this study came from 491 purebred, crossbred, and crossline gilt-farrowed spring pigs raised on pasture at the Indiana station in the years 1947–49; 606 three- and four-breed crossbred gilt-farrowed fall pigs raised at Lincoln, Nebraska, in the years 1947–50; and 797 inbred Duroc spring and fall pigs raised by gilts and yearling sows at the North Platte, Nebraska Station during the years 1948–50. The data thus come from herds varying both in genetic make-up and in management practices.

Analyses presented are those involving birth weights, 56-day weights, and 154-day weights. Only data on pigs which were alive at 154 days are included.

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Experimental Results

The mean levels of performance for the pigs are presented by stations in table 1. The average birth weights in the three sets of data are similar. After birth, however, the Indiana pigs grew faster with the result that 56-day and 154-day weights are heavier than in any Nebraska group except Lincoln 1950 fall pigs.

TABLE 1. MEAN PIG WEIGHTS FOR THE THREE AGES BY STATIONS AND YEARS

Station, Year and Breeding Group	No. Pigs	Birth Weight	56-Day Weight	154-Day Weight
		lb.	lb.	lb.
Indiana (all spring)				
1947	123	2.8	39.2	203
1948	183	2.7	35.2	184
1949	185	2.7	37.6	189
Nebraska				
Lincoln (all fall)				
1947	126	2.9	30.5	149
1948	179	2.8	27.9	143
1949	141	2.4	30.0	151
1950	160	2.5	31.8	187
North Platte				
1948 (fall)	170	2.7	26.3	108
1949 (spring)	368	2.9	29.1	122
1949 (fall)	75	2.7	25.7	108
1950 (spring)	85	2.9	24.0	111
1950 (fall)	99	2.8	28.1	154

The total and within-litter simple correlation and regression coefficients between individual pig weights at three ages at the three experiment stations and between weights at two ages and gains during a subsequent period of growth are given in table 2. The total correlations and regressions for each station include seasonal effects, differences between lines of breeding, and litter effects as well as the within-litter relationships. The two figures are in all but one case of similar magnitude, but because of freedom from these complications, the within-litter figures are used in this discussion. In a few cases correlations differed significantly from year to year at the same station. For purposes of presentation, however, all data from a station have been pooled in the belief that the pooled figures, while not strictly valid from a statistical standpoint, give the best estimate of overall relationships at

TABLE 2. SIMPLE CORRELATION AND REGRESSION COEFFICIENTS BETWEEN INDIVIDUAL PIG WEIGHTS AT THREE AGES AT THREE EXPERIMENT STATIONS

Item	D/F	Items Correlated *									
		Birth Wt.—56 Da. Wt.		Birth Wt.—154 Da. Wt.		56 Da. Wt.—154 Da. Wt.		Birth Wt.—Gain, Bir. to 56 Days		56 Day Wt.—Gain, 56 to 154 Days	
		r	b	r	b	r	b	r	b	r	b
Indiana:											
Total	490	.58	8.8	.42	22.4	.69	2.4	.52	7.7	.49	1.4
Within litter	418	.51	7.6	.41	23.2	.66	2.5	.41	6.1	.44	1.4
Nebraska: (Lincoln)											
Total	605	.38	4.4	.14	8.2	.57	3.0	.31	3.4	.42	2.0
Within litter	489	.55	6.2	.35	20.4	.55	2.8	.43	4.6	.38	1.8
Nebraska: (North Platte)											
Total	796	.46	5.5	.37	17.9	.60	2.4	.39	4.4	.35	1.4
Within litter	649	.54	6.3	.44	19.2	.70	2.6	.40	4.6	.50	1.8
Averages: (within stations)											
Total	1882	.46	6.2	.31	16.2	.62	2.6	.40	4.9	.41	1.6
Within litter	1547	.53	6.7	.40	20.9	.63	2.6	.41	5.1	.45	1.7

* All coefficients are statistically highly significant (P is less than .01).

the various stations. Similarly, coefficients differ significantly between stations in some cases, but have been averaged for presentation.

Correlations between weight at a given age and weight at a later age are in part automatic since the earlier weight is part of the later one. For this reason relationships between weight at a given age and gain during a subsequent period are also presented.

Our figures confirm those of numerous other workers in indicating average positive relationships between birth weight and 56-day weight ($r=0.53$), birth weight and gain from birth to 56 days ($r=0.44$) and birth weight and 154-day weight ($r=0.40$). While these correlations are all highly significant statistically and the associated regressions (table 2) are large enough to indicate the desirability of heavy birth weights, the coefficients of determination (correlation coefficients squared) indicate that birth weight is a relatively poor indicator of future weights or gains. Birth weight accounts for only 28, 16, and 17 percent of the variance in 56-day weight, 154-day weight, and gain from birth to 56 days of age, respectively.

Weight at 56 days is positively correlated with 154-day weight ($r=0.63$) and with gain from 56 to 154 days of age ($r=0.45$) but is a relatively poor indicator of either of these items accounting for only 40 and 20 percent of the variances, respectively.

Additional analyses not given in detail here showed a correlation of 0.49 ($r^2=0.24$) between average weights of pigs in different breeding groups or sire progenies at 56 and 154 days of age and a correlation of 0.67 ($r^2=0.45$) between litter averages within breeding or sire groups at these ages.

The foregoing data based on individual pig weights, or on average pig weights by breeding groups and litters, indicate positive but relatively low associations between weights at early ages and ensuing gains or weights at later ages. Although the specific ages and weights differ somewhat, these observations are in general agreement with those of Smith and Donald (1939), Hazel *et al.* (1943), Comstock *et al.* (1942), and Miranda *et al.* (1946), in indicating a low predictability of weight at a given time on future gains in pigs. Our data as well as the earlier figures suggest that swine production testing programs may fall far short of their objectives if they are based on the premise that individual 56-day weight is a good indicator of weight at ages near which pigs are usually marketed in this country. This is particularly true if selection of heavy pigs at 56 days is depended upon as a substitute for selection of heavy weights at the later age.

Baker *et al.* (1943) as well as others have shown that heritability of weaning weight is low, about 15 percent. In their data litter environment, largely maternal influence, accounted for 48 percent and individual environmental effects accounted for 37 percent of the variance in weaning weight. These facts as well as the present correlations between weaning and 154-day weight and weaning weight and post-weaning gain indicate the probable lack of effectiveness of selecting for individual pig weights at young ages. The work of Hazel *et al.* (1943) and Blunn *et al.* (1953) indicates that gain from 56 to 112 days of age offers greater possibilities for use in selection for increased growth rate than does weaning weight.

The usual observation that heavy litters at 56 days of age are also heavy at later ages is borne out by our data which in the Indiana figures showed a within breeding-group correlation of 0.96 between total litter weights at 56 and 154 days of age. Most of this correlation depended upon number of pigs per litter which also had a correlation of 0.96 with total litter weight at 154 days. This indicates that selection of litters with large numbers of pigs alive at 56 days of age would accomplish nearly as much in selecting for heavy litters at 154 days of age as would selecting litters on the basis of weight at 56 days of age.

Summary

The interrelationships of birth, 56-day and 154-day weights for 1894 pigs raised at the Indiana and two Nebraska experiment stations are presented. The average within-litter correlations were, birth-weaning weight 0.53, birth-154-day weight 0.40, and 56-day-154-day weight 0.63. The coefficient of determination (r^2) of the 56-day weight on 154 day weight is .40 indicating that a knowledge of 56-day weight accounts for only 40 percent of the variance in 154-day weight. Selecting heavy pigs at 56-days in order to increase weight at 154-days can thus be expected to have only a low efficiency. Due principally to number of pigs, the relationship between total litter weights at 56 and 154 days of age is high.

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SELECTION OF PIGS UNDER FARM CONDITIONS: KIND AND AMOUNT PRACTICED AND A RECOMMENDED SELECTION INDEX [1]

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ESTIMATES of selection intensities, selection differentials, herd and breed means, variances and covariances for economically important characters in swine are available in reports based on experiment station records (Whatley, 1942; Hazel, 1943; Comstock and Winters, 1944; Blunn *et al.* 1953; Dickerson *et al.* 1954). Also from experiment station data, a swine selection index was developed and the principle of index selection illustrated by Hazel and Lush (1942) and Hazel (1943).

The purpose of the present study is to provide comparable statistics from Wisconsin farms and to construct a selection index for pigs raised under these conditions.

Data and Procedure

The data used in this study were collected over a period of six years, 1947–1952. The major part of the data comes from one-sire herds enrolled in the Wisconsin Swine Selection Cooperative (W.S.S.C.). The records from these herds up until 1948 include the number of pigs per litter at birth, at 56 days and at 154 days as well as the weight of each pig at 56 and 154 days. The breed and age of both sire and dam are also recorded. Starting in 1949, no weaning information was collected from these herds but the 154-day information was still recorded. Two-sire herds in which inbred and non-inbred boars were compared (Durham *et al.*, 1952) provide the remainder of the material for this study. In these herds, weaning and 154-day information was gathered each year.

As a rule, the weaning weights of the pigs on a farm are taken on a single day; the "five-month" weights are also taken on a single day.

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These weights are adjusted to the 56-day equivalent for the weaning weights and to 154 days for the five-month weights, using correction factors computed by Whatley and Quaife (1937) and Lush and Kincaid (1943), respectively.

From a duplicate of the farm records maintained by the University, a selection index is calculated for each pig in the W.S.S.C. The farmer is sent a list of his highest indexing gilts so as to help him select his breeding stock on the basis of these indexes.

The indexes used in this project are adapted from the studies of Lush (1938, 1940a) and Hazel (1943), and are as follows:

(a) herds with records at birth, weaning time, and five months:

$$I=N_F+2N_W+\frac{W_{LW}}{15}+0.7\ (W_{I154}-74)$$

(b) herds with records at birth and five months only:

$$I=N_F+2N_{154}+\frac{W_{L154}}{100}+0.7\ (W_{I154}-74)$$

where: N_F=number of pigs farrowed
N_W=number weaned
N_{154}=number at 154 days
W_{LW}=litter weight at weaning
W_{L154}=litter weight at 154 days
W_{I154}=pig's own weight at 154 days

In each index the sum of the first three items in the equations is referred to as sow productivity.

A total of 161 herds and 969 litters is involved in this study. All litters are outbred and out of gilts. Since each breed was not represented by large numbers, within- and between-breed analyses were not made.

Lush (1940b) pointed out the advantages of the intra-sire regression of daughter on dam over the corresponding correlation for estimating heritability. Regressions were used here for estimating both heritability and genetic correlations. Since most of the herds in this study used only one sire per generation, it was not possible to separate the genetic from the environmental variation and covariation by analysis of the data within generations.

The relative economic importance of the traits studied was determined by the procedure given by Karam *et al.* (1953) in the construction of a sheep selection index. This was combined with the phenotypic and genotypic variances and covariances to construct a selection index in the way outlined by Hazel (1943) with a modification suggested by Henderson (1951, unpublished).

Results

Means and Variances

There is an increase in mean sow performance from 1948 to 1952, especially in litter size at birth and at five months of age (table 1). However, the herds which remained in the program for at least three years show no consistent increase in any component of sow productivity from one year to the next. Hence the time trend reflected by these data arose primarily from the superiority of the herds which are added to the program each year over those which did not remain in the program from the previous year.

The standard deviations (table 1) are in agreement with most of those published earlier (Whatley, 1942; Baker *et al.*, 1943; Nordskog *et al.*, 1944; Stewart, 1945). However, data on the inbred lines at the experiment stations in the Regional Swine Breeding Laboratory show standard deviations approximately 25% higher (Dickerson *et al.*, 1954).

Selection Intensity and Differentials

Theoretically, in herds of constant size, averaging 6.7 pigs raised per litter, one would have to maintain an intensity of selection of about 30% for complete replacement of sows by gilts each year. This is 6% higher than the over-all intensity calculated from these records. This discrepancy is undoubtedly due to the fact that within a herd all litters whose dams could not be identified from the pig records of the previous year were excluded.

The total selection differentials for litter characteristics have been broken down into the "conscious" and the "automatic". The automatic selection differential is the difference between the mean with each litter record weighted in accordance with the number of pigs alive at 154 days and the mean of the herd with each litter record given equal weight. The amount of selection practiced in addition to the automatic selection is the conscious selection.

When selecting for a single normally distributed character, a selection intensity of 30% would allow a selection differential of about 1.16 standard deviations. For 2 and 4 independent characters, the selection differential for each character would be .82 and .58 of a standard deviation respectively. Therefore, recognizing the correlation between litter characters and the independence of variation between individual and litter characters, the maximum selection differential for each trait studied here would lie in the range of 0.6 to 0.8 of a standard deviation. The calculated differentials (table 2) are of the

TABLE 1. MEANS AND INTRA-HERD STANDARD DEVIATIONS

Year	Number Herds	Number Litters	Number Farrowed		Number 154 Days		Weight Litter 154 Days		Sow Productivity		Weight Pig 154 Days		Index	
			Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
1948	24	154	8.4	1.9	6.3	1.9	820	255	44[1]	8	129	21	86[1]	17
1949	28	186	8.7	2.2	6.2	1.9	818	261	40	8	133	26	86	19
1950	45	222	8.8	2.2	6.7	2.0	899	299	42	9	135	22	89	17
1951	32	178	9.0	2.1	6.8	1.8	866	241	41	7	127	22	82	18
1952	32	229	9.2	1.9	6.7	1.9	990	262	43	7	142	22	94	16
Total and ave.	161	969	8.8	2.0	6.7	1.9	886	265	42	8	134	23	88	17

[1] Based on number of pigs weaned and weight of litter weaned instead of number and weight at 154 days in 1948.

TABLE 2. CONSCIOUS AND AUTOMATIC SELECTION DIFFERENTIALS[1] IN ACTUAL UNITS

Year	Number Farrowed		Number 154 Days		Weight Litter 154 Days		Sow Productivity		Weight Pig 154 Days
	Conscious	Automatic	Conscious	Automatic	Conscious	Automatic	Conscious	Automatic	Conscious
1948	.26	.31	.40	.45	65.9	67.6	1.96	1.83	8.85
1949	.31	.40	.46	.55	81.9	64.5	2.27	2.23	8.21
1950	—.05	.32	.24	.47	70.3	55.1	1.19	1.81	10.17
1951	.22	.32	.41	.49	89.2	53.2	1.81	1.86	9.66
1952	.15	.30	.13	.40	79.4	51.9	1.77	1.59	11.56
Ave.	.16	.32	.31	.47	77.3	57.7	1.73	1.85	9.8

[1] The differentials of litter characteristics are based on dams' performances; they have to be divided by two when applied to the selection of offspring.

order of 0.25 of a standard deviation for number farrowed, 0.4 for number of pigs per litter at 154 days, 0.5 for litter weight and 0.6 for individual weight at 154 days, indicating that the breeders did not make full use of the available variation in these traits when selecting their breeding stock.

Dickerson *et al.* (1954) reported the selection practiced during the development of inbred lines in the Regional Swine Breeding Laboratory. The total (automatic and conscious) differentials in actual units over all stations and inbred lines were between 1.3 and 1.6 times as large as those found in these data, the selection intensity being 33%. In standard deviation units, the difference between the two studies in the size of the total selection differentials is very small. On the other hand, the conscious selection differentials for the experiment station herds are negligible for litter size, while they are approximately 1/3 of the total differentials in these data. For litter weight, the conscious selection differentials are of the same order of magnitude in both studies.

The actual selection differentials were compared to those that would have resulted on index selection alone if all of the higher indexing gilts could have had and were allowed to have a litter. To make this comparison, the gilt pigs within herds were listed in descending order on index. From the top of the list were taken as many gilts as were kept for breeding and raised litters the following year. These "potential breeders" (highest indexing gilts) gave selection differentials 1.5 times as large for numbers farrowed and at 154 days and twice as large for individual weight as those actually selected. These differences in selection differentials are due to the fact that about half of the gilts selected each year were not from the highest indexing gilts.

Estimates of Heritability

Heritability was estimated in this study by doubling the intra-sire regression of daughters on dams. As such, it contains all of the additive genetic variance and probably some of the epistatic deviations (Wright, 1935), but still allows the breeder to predict the approximate amount of genetic improvement he should obtain from a given selection differential.

The estimates of heritability obtained from these data are: for number farrowed, .07; number weaned, .06; number at 154 days of age, .09; litter weight at weaning, .02; litter weight at 154 days, .11; and for individual pig weight at 154 days, .10. These estimates are lower than most of those published by other workers on the same

characters at corresponding ages, but the sampling variances of these statistics are large and none of them is significant. From a review of some of the reports in the literature (Dickerson and Grimes, 1947; Phillips, 1947; Blunn and Baker, 1949; Cockerham, 1952; Blunn *et al.*, 1953) the bulk of the evidence suggests that: (1) the heritability for litter size probably does not exceed 0.18; (2) the heritability of litter weight is around 0.1; (3) the heritability of individual weight increases with age, is somewhat larger than the heritability for items of sow performance, and is probably about 0.2 at 154 to 180 days of age.

Phenotypic Correlations

The within-herd phenotypic correlation coefficients are given in table 3. Those between litter characteristics (x) and average individual weight ($\bar{y}$) were put on the basis of individual paired observations by the following transformation:

$$r_{xy}=r_{x\bar{y}}\sqrt{[1+(n-1)\ r_{y_iy_j}]/n}$$

where $r_{y_iy_j}$ is the correlation between 5 month weights of litter mates and n is the harmonic mean of the number of observations on which $\bar{y}$ is based. The full-sib correlation was deduced from an analysis of variance. Its value of .30 is well in agreement with the one of .31 found by Hazel (1943) on 180-day weight of Poland China pigs.

The correlations between litter characteristics are all significant (P less than .01). Those involving individual pig weight do not differ significantly from 0; they were given the value of 0 in the construction of the index.

Genetic Correlations

Hazel (1943) outlined the method of calculating genetic correlations. They were estimated in this study by the formula,

$$r_{G_xG_y}=\sqrt{b_{xy'}\cdot b_{yx'}/b_{xx'}\cdot b_{yy'}}$$

where the b's refer to the regressions of daughters on dams within sires for characters x and y and where the primes refer to records on the dams.

The estimates of genetic correlations involving number farrowed are 1.3 with number of pigs per litter at 154 days and 1.6 with litter weight at 154 days. These values were regarded as an indication that the true genetic correlations are at least positive. They were given some-

TABLE 3. INTRA-HERD PHENOTYPIC CORRELATIONS OVER ALL YEARS

Item	Number Weaned	Weight Litter Weaned	Number 154 Days	Weight Litter 154 Days	Weight Pig 154 Days	Sow Productivity	
						56 Days	154 Days
Number farrowed	.67**	.52**	.49**	.39**	—.02	.75**	.62**
Number weaned		.82**	.91**	.82**		.95**	
Weight litter weaned			.74**	.83**		.91**	
Number 154 days				.91**	—.004		.97**
Weight litter 154 days					.01		.93**
Weight pig 154 days							.01

** Significant at P less than .01.

what arbitrarily the value of 0.5 in the calculation of the index. Between the number of pigs per litter and the litter weight at 154 days, the estimate is .77. Individual pig weights and the characteristics of the litters in which the pigs were born and raised show no evidence of being associated genetically. Hazel (1943) obtained the same result between 180-day weight of Poland China pigs and the sow productivity (based on weaning information) of their dams.

The magnitude of these genetic correlations is still very uncertain. However, with heritabilities of the order of 0.1 to 0.2, a wide variation in the size of genetic correlations can cause only a slight change in the relative emphasis given to the characters in the index.

Relative Economic Importance

It is assumed here that pigs are paid for on the basis of live weight only. Total income is therefore considered to be dependent on the number of pigs per litter and their rate of gain. Live-hog backfat measurements as described by Hazel and Kline (1952) or other measures of carcass quality as well as other measures of the animal's worth should be included in an index when the demand for them and the information on them warrant their inclusion.

The procedure followed in this study is to compare the increase in net income from one unit change in number of pigs per litter at 154 days of age to that from one unit change in individual weight at 154 days. This is predicated on the assumption that the relative economic importance of litter size and individual weight at 5 months is a good reflection of the relative economic value existing between litter size and age at market time.

On this assumption, the relative economic importance of these characters can be estimated from a comparison of the increase in five month weight per pig (constant litter size at five months) with the increase in litter size at five months (constant individual five month pig weight) needed to produce a given increase in pork production. In these data, where the average five month pig weight is 134 pounds and the number raised per litter to five months is 6.7 (table 1), an increase of one pound in each pig's weight at five months would be equivalent to an increase of 1/20 of a pig per litter. Hence, one additional pig per litter is worth as much in terms of net profit as 20 pounds additional five month pig weight. It is unlikely, on the basis of our data, that this ratio would be outside the range of 15:1 to 30:1, corresponding to means for litter size and individual weight of

eight pigs and 120 pounds, and five pigs and 150 pounds, respectively. Because litter size is based on dam's performance and five month weight on the individual's own performance the ratio used in construction of the index was $\frac{20}{2}$:1 or 10:1.

The assumption that a given increase in amount of pork produced may be obtained at the same cost either by increasing the average litter size or by increasing the weight of each pig appears to be approximately correct. The extra cost of raising one more pig to 134 pounds was estimated from the increase in feed consumed by the sow during the suckling period and the feed consumed by the pig from weaning to 134 pounds. The estimated cost of increasing the weight at 154 days of each of 134 pigs by one pound is approximately the same.

Index

The details for constructing selection indexes have been presented by Hazel (1943) and Karam *et al.* (1953). Both procedures are based on the same genetic principles and, with a given set of parameters, both lead to the same index. The latter method was suggested by Henderson (1951, unpublished) and is one which allows an easier modification of the index when there is a change in the relative economic values of the traits involved.

The breeding value of an animal may be represented by:

$$H=a_1G_1+a_2G_2+ - - - +a_nG_n$$

where each G_i represents additive effects of the genes determining X_i, and a_i is the relative economic value of each G_i. Let the variable I_i be the best possible measure of G_i, utilizing the information on all X_i's. Then,

$$I_i=b_{i1}X_1+b_{i2}X_2+ - - - +b_{in}X_n$$

The b's are regression coefficients calculated in such a way as to maximize $r_{I_iG_i}$. The best estimate of the breeding value of an individual is:

$$I=a_1I_1+a_2I_2+ - - - +a_nI_n$$

Since litter size and individual weight are the two traits with direct economic importance, the first being 10 times as important as the second,

$$H=10G_1+G_2 \text{ and } I=10I_1+I_2$$

Four indexes were calculated to predict H from the phenotypic and genotypic variances and covariances given in tables 4 and 5:

TABLE 4. PHENOTYPIC VARIANCES[1] AND COVARIANCES USED IN COMPUTING THE INDEX

Item	Number Farrowed	Number 154 Days	Weight Litter 154 Days	Weight Pig 154 Days
Number farrowed	*4.05*	1.90	210	0
Number 154 days		*3.69*	463	0
Weight litter 154 days			*70,133*	0
Weight pig 154 days				*521*

[1] Variances are in italics.

(a) An index using number of pigs per litter (X_2) and individual weight (X_4) at 154 days.

$$I_a = .950X_2 + .103X_4$$

$$r_{I_aH} = .394$$

(b) An index using the number of pigs per litter at birth (X_1) and at 154 days (X_2) and the individual weight (X_4) at 154 days.

$$I_b = -.070X_1 + .990X_2 + .103X_4$$

$$r_{I_bH} = .395$$

(c) An index using the number of pigs per litter, (X_2), the litter weight (X_3) and the individual pig weight (X_4) at 154 days.

$$I_c = 1.330X_2 - .003X_3 + .103X_4$$

$$r_{I_cH} = .397$$

(d) An index using the number of pigs farrowed (X_1), the litter size (X_2), litter weight (X_3) and individual pig (X_4) weight at 154 days.

$$I_d = -.102X_1 + 1.459X_2 - .004X_3 + .103X_4$$

$$r_{I_dH} = .399$$

TABLE 5. GENOTYPIC VARIANCES[1] AND COVARIANCES USED IN COMPUTING THE INDEX

Item	Number Farrowed	Number 154 Days	Weight Litter 154 Days	Weight Pig 154 Days
Number farrowed	*.28*	.16	23	0
Number 154 days		*.35*	40	0
Weight litter 154 days			*7855*	0
Weight pig 154 days				*54*

[1] Variances are in italics.

Discussion

The purpose of this study was to investigate some of the factors which influence progress from selection and to construct an index for selecting young pigs under farm conditions. The sample of herds is probably large enough to characterize the population phenotypically, but not large enough to give much precision to the estimates of genotypic parameters.

The selection differentials on the farms studied are 0.5 to 0.7 as high as those that would have resulted if index selection alone had determined which gilts would farrow the following spring. Infertility and other abnormalities are certainly selected against, but they can hardly account for the culling of approximately 50% of the highest indexing gilts within herds. Neither weight on a given day nor age at a given time appears to be a consistent influence in their selection (Chung, 1953, unpublished). From the analysis of Dickerson *et al.* (1954) there is some evidence that in the herds in the Regional Swine Breeding Laboratory conformation was emphasized more than the other items of performance in selecting gilts. There is the possibility in the herds studied here that type and details of conformation also played a role in the choice of breeding stock, but their influence cannot be evaluated from these data.

The estimates of heritability obtained in this study are lower than most of those reported previously. The large sampling variances of such estimates makes it difficult to tell whether or not these differences are real. Because the index emphasized the traits involved proportionately to their genetic variance, the final emphasis given to the traits would not change appreciably if the genetic variances used were those estimated from the heritabilities reported in most of the other studies.

Four indexes were calculated to estimate the relative genetic value of 5-month old pigs within herds. In each index, individual weight has an emphasis equal to its heritability, due to the fact that its relative economic value is unity and that it does not appear to be correlated either phenotypically or genotypically with any of the other traits considered. Litter size at 154 days goes into each index because it is probably the best single estimate available of the genic value of the number of pigs per litter at market time. These two traits together (I_a) can estimate the genetic value of the animals .394 as accurately as if the genetic constitution of each animal were completely known.

The precision of the index can be increased a small amount by incorporating number farrowed and litter weight at 154 days. The main contribution of these two traits is in cancelling some of the environmental deviations in litter size at 154 days. This is reflected by the negative emphasis placed on those traits (they have a positive environmental correlation with litter size at 5 months) while the emphasis on litter size at 154 days is increased.

The index which best depicts the aggregate genotypic merit of the young pigs (I_d) is only slightly superior to the other indexes in terms of its correlation with the aggregate genotype (r_{IH}=.399) but it includes items of performance easily available. For easier calculation this index may be simplified to:

$$I'_d = -.5X_1 + 7X_2 - .02X_3 + .5X_4$$

where X_1 is the number farrowed, X_2, X_3, and X_4 represent the litter size, litter weight and the individual pig weight at 154 days, respectively.

The differences in the individuals which would be included in the selected group of pigs when I_a is used as compared to I_d is generally so slight that the following modification of the simpler index is recommended for general use:

$$I'_a = 4.5X_2 + 5X_4$$

The data in this study come from purebred and crossbred stock with most of the American breeds represented. Therefore, the proposed indexes are believed to be applicable to most herds maintained under the conditions specified by the population sampled. The purebreds, although separated for several decades, probably differ only slightly in their expression of phenotypic and genotypic variances and covariances with respect to the traits involved in the index. However, it may be that the relative economic values of the traits vary appreciably from breed to breed. For example, a breed may be low in productivity but not in rate of gain (Bradford *et al.*, 1953), in which case productivity should be given more emphasis relative to rate of gain than it is in this study.

If a herd is made up of sow and gilt litters, it is important to put the pig indexes on a common basis by adjusting for the change in litter size at birth and 5 months and in litter and individual weight at 5 months from the first to the second and following litters. The results reported by Lush and Molln (1942) and an intra-sow comparison within our data show an increase of about 1½ pigs farrowed and 1 pig weaned from gilt litters to sow litters one year later. Similar analyses of our data on 154-day litter weights and individual pig

weights show increases of 257 and 14 pounds, respectively. If these figures are representative, subtracting 8 points from I'_d or 11 points from I'_s would place the index of pigs out of sows on the same basis as the index of pigs out of gilts.

There is need for greater precision in the statistics which enter into the index, particularly in the estimates of genetic parameters. Likewise, the economic values of the different traits need to be studied from the standpoint of the causes of variation in net income within herds. Collection and analysis of additional farm records are being made to help in clarifying these problems.

Summary

The records analysed in this study were collected on Wisconsin farms during the period 1947–1952. Data were available for at least two consecutive years on each herd studied. A total of 161 herds with 969 litters by 218 sires are involved. The characters studied are the number of pigs per litter at birth and at 154 days of age, the litter weight and the individual pig weight at 154 days.

The average total selection differentials in actual units are .48 and .78 of a pig for litter size at birth and at 154 days respectively, 135 pounds for litter weight and 9.8 pounds for individual pig weight at 154 days. One-half to three-quarters of the selection practiced for litter characters was automatic.

The estimates of heritability vary from .07 to .11 and are not significantly different from 0. Since they are the best estimates available on the population sampled, they were used in calculating the genetic variance for each trait.

The phenotypic correlations between litter characters vary from .39 to .91, the largest standard error being .03. Those between litter characteristics and individual pig weight are close to 0. The estimates of genetic correlations between litter characteristics are highly positive. However due to the size of their sampling variances, there is considerable doubt as to their true magnitude. The estimates of genetic correlations involving individual pig weight indicate very little if any genetic association between those traits.

The relative economic importance of litter size and individual pig weight at 154 days of age, in terms of net income, probably lies within the range of 15:1 to 30:1, with an average ratio of 20:1. Number farrowed and litter weight at 5 months were given no direct economic importance, but were included in the index as an aid in predicting the

genetic differences between animals with respect to litter size at 154 days.

The index which best estimates the transmitting ability of 5-month-old pigs is:

$$I'_d = -.5X_1 + 7X_2 - .02X_3 + .5X_4$$

where the subscripts 1 to 4 refer to the number farrowed in the litter in which the pig in question is born, and the number in the litter, the litter weight and the individual pig weight at 154 days of age, respectively. It is correlated .399 with the aggregate genotypic value of the pigs.

A somewhat simpler index and with approximately the same precision in estimating the transmitting ability of a pig for its economically important traits is:

$$I'_n = 4.5X_2 + .5X_4$$

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THE MEASUREMENT OF WATER EVAPORATION FROM LIMITED AREAS OF A NORMAL BODY SURFACE

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A MEANS of measuring the rate at which water is evaporated from a defined area of normal body surface is necessary for the following reasons amongst others: (a) to reveal the evaporative significance of different areas, especially of appendages, thought to play an important role in heat regulation; (b) to permit studies of the effect of altering local conditions (blood flow, gland activity, hair length, etc.) upon evaporation; (c) to permit estimation of blood flow through the conduct of partitional calorimetry of an area.

Current methods of measuring water evaporation from a defined area of body surface (Pinson, 1942; Randall and McClure, 1949) usually expose the skin to relatively dry air, either by drawing pre-dried air over the skin and through an absorber whose change in weight is measured, or by absorbing water vapor close to the skin with a strongly hygroscopic material. Such methods expose the skin to atmospheric conditions which may be markedly different from true ambient conditions; almost certainly draw off an unknown quantity of water previously stored in the superficial epidermis, hairs, etc.; and create a vapor pressure gradient between the test area and surrounding areas which may draw important quantities of water in from outside.

The method described here is designed to keep the test area exposed to virtually ambient conditions, and yet provide a good measure of the water evaporated under these conditions.

Principle

Air is recirculated by a pump alternately through a capsule applied to the test area and through an absorber containing a saturated solution of a suitable salt (figure 1). The air leaves the absorber in equilibrium with the solution, and thus has a vapor pressure determined

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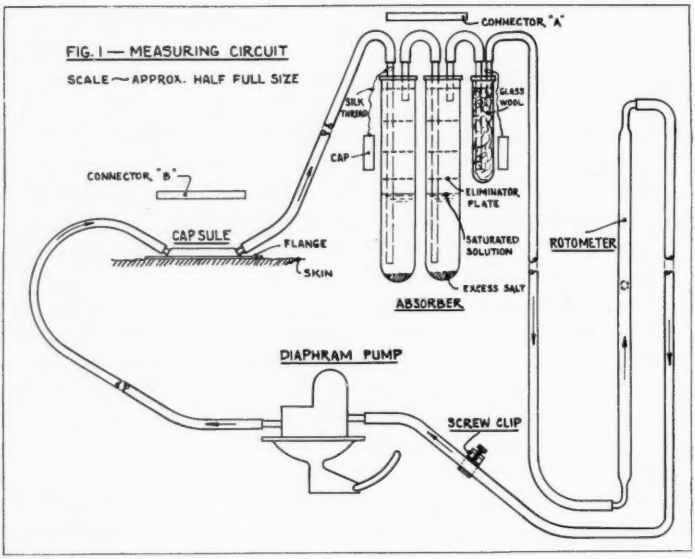
by the nature of the salt and the temperature of the solution. The salt can be chosen to give a vapor pressure close to that of the ambient conditions of the study. The water vapor content of the circulating air is increased by evaporation from the surface under the capsule,



but this extra water vapor is then taken up by the saturated salt solution without changing its own vapor pressure (as long as it remains saturated.)

As long as there is no leak between the system and the outside air, and no exchanges between the circulating air and the tubing, the rate of deposition of water in the absorber must equal the rate of evaporation from the skin.

The rate of evaporation is given (Hardy, 1949) by:

$$E = k\frac{(v)^{0.5}}{(d)} w(P_s - RP_a)$$

where v is rate of air movement
d is a dimensional constant
w is wetness of skin in terms of unity
P_s is saturation vapor pressure at temperature (t_s) of skin

R is relative humidity of air leaving absorber
P_a is saturation vapor pressure at temperature (t_a) of absorber
k is a constant depending on the units employed.

If the rate of moisture production on the skin changes, w will tend to change correspondingly, with a resultant change in evaporation and absorption and the establishment of a new equilibrium. With a certain time-lag, therefore, the rate of weight gain in the absorber will indicate the rate of water production on the skin and variations therein, provided that the remaining factors (v, P_s and P_a) are kept constant.

If v, P_s or P_a are changed, the last two usually by change in t_s and t_a, w will increase or decrease until a new equilibrium is obtained. After a certain time lag, therefore, the rate of weight gain the absorber will again equal the rate of water production in the skin—provided that at no time in these variations w rose to the saturation value of 1.

If repeated weighings are made over a period of time, both the time lags and the equilibrium values will become evident. If measurements are made of t_s and t_a at the same time, further calculations on heat transfer and its distribution between the conductive and evaporative channels can be made.

Apparatus

Circuits

Two circuits are set up. *The measuring circuit* (figure 1) consists of a diaphragm pump, the capsule in which the evaporation is being measured, an absorber which is carefully weighed and handled, and a rotometer to measure the volume of air flow, connected in that order by heavy rubber tubing (red, medium wall, 3/16 inch bore); with a screw clamp on the tubing between the rotometer and the pump to permit the adjustment of air flow to the desired level. Short pieces of glass tubing "a" and "b" are provided as substitute connectors for the absorber and capsule respectively (see later—Operation).

A maintenance circuit (figure 2) is also necessary to maintain air flow through all capsules in which measurement is not at the moment being made. Unless this is scrupulouslly carried out, water will accumulate in the capsule and give unduly high readings in subsequent measurements. In this circuit each capsule in which measurement is not being made at the moment is connected by rubber tubing to an

absorber. Each absorber is connected to a rotometer, and the various rotometers are connected to a common line entering a second diaphragm pump. The common output of the pump is connected by branch lines to the various capsules. Screw clamps on the lines from the rotometers permit adjustment of the air flow in each individual circuit to the

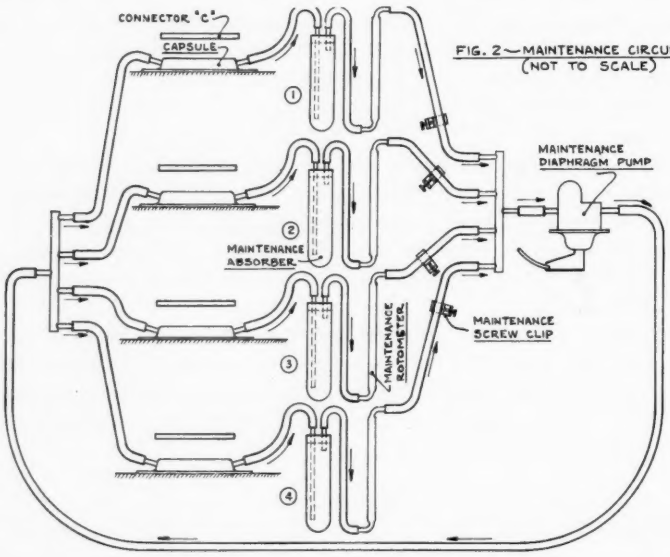


FIG. 2—MAINTENANCE CIRCUITS (NOT TO SCALE)

desired level. When it is desired to measure the evaporation in a given capsule, that capsule is quickly connected to the measuring circuit instead of to the maintenance circuit. At the end of the measuring period the capsule is connected to the maintenance circuit again. It is essential that all parts of the circuit be impermeable to water vapor. Glass and rubber should be used, rather than plastic and cork.

Capsule

The capsule consists of a fairly thin (20 gauge) copper sheet pressed over a mold to give a central chamber 5 cm. long, by 2 cm. wide, by 0.5 cm. high, and open below. The lower edge of the wall is continuous with a flange at right angles to it, which extends outward for 1–2 cm. all around. An inlet tube is inserted at one end and an outlet tube at the other.

The flange is covered with chalk and then pressed against the animal at the desired location. If the surface is irregular the flange of the capsule is bent to fit contours of the surface. A small animal clipper is used to remove the hair indicated by the chalk as the location of the flange. Precaution is taken to insure that the hair which will be under the capsule is not disturbed. After the hair has been removed the chalk is rubbed off the flange and a layer of rubber cement (Pliobond) is placed on both the chalked skin and the flange of the capsule. When the cement has dried somewhat, the capsule is applied to the skin and held firmly in place until the cement has set. Setting is hastened by a draft of air from a hair dryer.

Absorber

The absorber (figure 1) consists of two glass test-tubes, each 150 mm. high by 25 mm. outside diameter, with rubber stopper, each carrying an input tube running to within 2 cm. of the bottom, and an output tube commencing just below the stopper. Three eliminator plates, each with 2 holes 0.5 mm. in diameter, and supported by the input tube, span each test-tube to break up bubbles and prevent splashing. The output of the first test-tube is connected to the input of the second. The output of the second is bent over to dip to the bottom of a smaller test-tube (a 10 ml. transparent plastic tube) containing glass wool to act as a final eliminator of liquid water particles. A final output tube emerges from a stopper closing the mouth of the small test-tube.

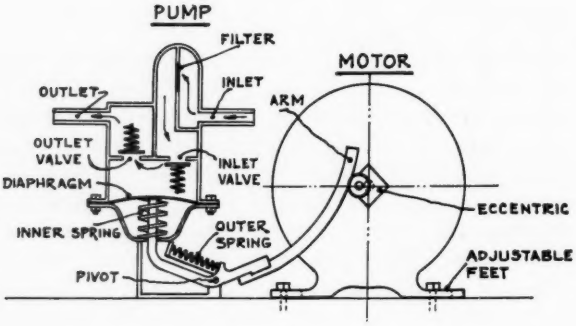
10 cc. of solution of the appropriate salt (Hodgman, 1948), saturated at the working temperature, is placed in each absorbing tube, and a few crystals of the salt added to ensure sautration. The three test-tubes are firmly bound together with rubber bands, and a wire loop added to hang the tubes on a balance. Glass caps are provided for the first input and final output tubes and tied to the assembly with light silk thread. All surfaces should be smooth and nonhygroscopic.

Pumps

The pumps (figure 3) used in the maintenance and measuring circuits are AC 551 fuel pumps (for heavy trucks) fitted with 5/16 inch copper tubing outlets. The pumps are each fitted with an extended arm resting on a cam shaft, driven by a 1/4 hp. electric motor and giving 1725 strokes/min. The diaphragm, which is made of thin sheets of impregnated cloth, is coated with rubber cement to help make

it vapor proof. The stroke is determined by the length of the extended arm. In this type of pump the circulating air does not come in contact with lubricants or crevices leading to the exterior, so that gains or losses of water vapor as it passes through the pump are reduced to a minimum.

FIG. 3 — DIAPHRAGM PUMP AND MOTOR



Rotometers

The rotometer consists of a slightly, but accurately, tapered, vertical tube, with the narrower end down, containing a solid glass ball. As air flows upward through the tube, the upward pressure of the air raises the ball to the point at which its escape through the gap between the ball and the tube reduces the pressure to that of the gravitational effect of the ball. The greater the air flow, the wider the gap required, and the higher the equilibrium position of the ball. The position is read from graduations on the wall of the tube, and the corresponding volume flow determined from the appropriate chart supplied by the manufacturer.

Balance

A chainomatic chemical balance is used to weigh the absorber quickly to .0001 gm. The balance must be in complete temperature equilibrium before it is used.

Operation

All apparatus is assembled in the test atmosphere. Circulation is started in the measuring circuit (figure 1), a short length of glass tubing (b) taking the place of the capsule. The absorber is carefully weighed periodically until a constant small blank is obtained. Handling of the absorber must be entirely with dry metal instruments, so that moisture, deliquescent salts, lint, etc. are not transferred to it. The period required is usually about two hours, but may be longer if the balance is colder than the test atmosphere at the beginning of the period.

As soon as the measuring circuit has been started for equilibration, circulation is started in the maintenance circuits (figure 2), short lengths of glass tube (c) replacing the capsules. Circulation is maintained for two hours, or until the measuring circuit has attained an acceptable blank.

The test animal is brought into the test atmosphere at a time appropriate to the study. If the immediate responses are to be studied, for example, it is not introduced until an acceptable blank has been obtained in the measuring circuit. If the responses after it has attained equilibrium are to be studied, however, it may be brought in at the same time as the apparatus or about 2 hours before the test.

Capsules are attached to selected areas, as described above, immediately before the animal's entry to the test atmosphere. Immediately after its entry, each capsule is connected to one of the maintenance circuits in place of the glass tube (c) previously connecting the leads. In making these connections, care should be taken not to pinch the tubing, or fluid may be sucked back from or blown out of the absorber by the pressure difference created.

When the first measurement is to be made, the pump of the measuring circuit is stopped, the absorber disconnected, the input and output of the absorber capped, and the rubber tubing of the circuit connected by a short length of glass tubing ("a" in figure 1). The absorber is carefully weighed to the nearest .0001 gm. and returned to the measuring circuit. The appropriate capsule is now disconnected from its maintenance circuit, and inserted in the measuring circuit in place of the glass tube ("b" in figure 1) connecting pump and absorber. The pump is now restarted, and the time noted. The tubes in the maintenance circuit formerly attached to the capsule are connected by a short length of glass tube ("c" in figure 2).

After a suitable interval, measured by a stop-watch, the pump in the measuring circuit is stopped; the capsule transferred back to the maintenance circuit; the absorber disconnected, and capped; and the circuit closed by inserting the glass tubes (a) and (b). The absorber is again carefully weighed.

Measurements on different capsules can be made in immediate succession, the second weight for the first reading being treated as the first weight for the second and so on.

Results

Some of the results obtained by the use of this technique are given by way of illustration. In these experiments the salt used was sodium bromide. A saturated solution of this salt maintains a relative humidity of 58 percent at 20° C. (Hodgman, 1948). At the working temperature of 40° C. used in most of the studies to be reported this might be somewhat lower, but would still not be far from the room condition of 60 percent. An air flow of 4 l/min. was maintained through each capsule, which would be capable of picking up 80 mg./min. before reaching saturation. The maximum uptake encountered in these experiments was only 12 mg./min., so that there was little danger of interference by saturation.

There is however, the possibility that the passage of air at this rate through the absorber may be too rapid for equilibrium to occur. Tests were run in which air of varying humidity was passed through an absorber and the water vapor in the air leaving the absorber collected in silica gel. It was found that a rate of 3 l/min. gave a constant leaving humidity of 63 percent with entering humidities between this and saturation; but that when the rate of flow was raised to 4 l/min., there was some excess of humidity in the leaving air, amounting to an additional 5 percent when the entering air was nearly saturated. It is unlikely that this deficiency interfered seriously with the results reported here, but 3 l/min. has been adopted for future operating practice.

Is is theoretically possible for some substance other than water to contribute to the weight gain of the absorber, but such a substance would have to be soluble in water, soluble in the lipoid mixture on the skin, and volatile. Until the presence of such a substance is demonstrated it seems advisable to assume that the transported vapor is indeed water vapor.

Sweating in man is far from being a steady phenomenon, even in a constantly maintained environment. Fluctuations occur under the most rigidly controlled conditions. It cannot be assumed that water vaporization from other mammals, whatever the mechanism responsible for furnishing the water, is any more stable. The accord obtained between successive measurements on the same area, as shown in tables 1 and 2, is therefore gratifying. Such variation as is introduced by

TABLE 1. EVAPORATION (MG. IN 5 MIN. FROM 10 SQ. CM.) FROM FOUR DIFFERENT AREAS ON ONE COW IN A HOT ROOM (100°F, 29 mmHg VAPOR PRESSURE)

Time	Neck	Withers	Paunch	Loin
11.00	36.2			
11.08		58.4		
11.16			38.1	
11.24				20.8
11.32	29.4			
11.40		51.9		
11.48			33.6	
11.56				20.3
12.04	27.6			
12.12		51.0		
12.20			37.4	
12.28				17.3

Cow introduced at 08.30.
Blank: 5.6 mg. in 30 min. (0.93 mg. in 5 min.)

experimental error would seem at least to be no greater than that which may be expected from physiological variability, and to have little significance in comparison with the differences which are being sought.

That different areas of the skin may have different evaporative rates under the same environmental conditions is supported by results such as that given in table 1, where the neck and loin show distinctly lower rates than the other two areas. A relatively low rate on the loin can be seen in most of our experiments to date, but it is not always observed.

That the evaporative rate varies markedly with environmental warmth can be seen from results such as that given in table 2, where the rates are considerably greater in all four areas under the hotter conditions. The proportional increase is greater in those areas with the lower rates under the less strenuous conditions. This latter phenomenon is consistent with the recruitment phenomena described for human sweat glands by Randall (1946) and may explain why differ-

ential rates are not always seen in our routine test atmosphere which is somewhat hotter (105° F., 34 mmHg).

As a more direct test of the inadequacy of mere diffusion for the supply of such quantities of water, measurements were made on the sides of rabbits exposed to the same hot conditions. The results showed practically no evaporation at all, or even a slight absorption of water

TABLE 2. EVAPORATION (MG. IN 5 MIN. FROM 10 SQ. CM.) FROM SAME COW IN WARM AND HOT ROOMS

Time From Beginning Exposure	Warm (81°F, 12 mmHg)				Hot (101°F, 30 mmHg)			
	Neck	Withers	Paunch	Loin	Neck	Withers	Paunch	Loin
2.08	7.0				29.7			
2.16		25.8				55.7		
2.24			15.4				36.2	
2.32				10.8				31.0
2.40	8.3				30.2			
2.48		20.1				51.9		
2.56			9.0				30.5	
3.04				4.8				27.2
3.12	5.2				28.2			
3.20		26.7				54.3		
3.28			13.2				24.9	
3.36				5.9				31.3
	Blank: 5.9 mg. in 30 min.				Blank: 5.8 mg. in 30 min.			

in the capsule. It would seem that the amount of water which can diffuse through even the thin rabbit skin, devoid of glands, provides no evaporative cooling in an atmosphere at 105° F. and 34 mmHg vapor pressure.

One of the primary reasons for developing this technique of measuring evaporation was to study the difference between Jersey and Sindhi-Jersey crossbred cows. These two groups of animals exhibit marked differences in the rise of rectal temperature when exposed to heat. It will be seen from table 3, however, that while the rate of evaporation from the forechest is somewhat greater in the Sindhi-Jersey crossbred animals, this difference is not significant; and, as far as the whole animal is concerned, is offset by lack of any difference in the paunch. Other areas have still to be investigated.

The technique reported here seems to be satisfactory; but the questions raised by its application obviously need considerably more study. Predominant among such questions is the long-standing problem of the mechanism responsible for furnishing the water for evaporation.

That it is thermoregulatory in nature is strongly suggested by the step increase with increased environmental warmth. That it is something more than diffusion through epithelium, and that it is truly due to a secretary process is suggested by the quantity evaporated. A rate of 55 mg. in 5 min. from 10 sq. cm. is equivalent to 660 gm./sq. m., hr; and this is quite a high rate of water evaporation from a sweating man,

TABLE 3. EVAPORATION (MG. IN 5 MIN. FROM 10 SQ. M.) FROM JERSEY AND SINDHI-JERSEY CROSSBRED COWS IN A HOT ROOM (105°F, 34 mmHg VAPOR PRESSURE)

	Jersey		Sindhi-Jersey	
Item	Forechest	Paunch	Forechest	Paunch
Mean	48.60	49.22	54.14	48.46
Standard error	3.286	2.103	3.859	3.694
Number	17	17	14	14

such as would occur when walking at 3½ mph on a summer day in the desert. (It is not suggested that the whole animal evaporates at this rate, but at least a part of the surface may be faced with a water mobilization problem approaching this magnitude.) It is, of course, probable that some of the water available from skin under the flange of the capsule, and denied normal evaporation, may be drawn into the capsule and evaporated therein; but the firm texture of the seal to be seen when a properly applied capsule is removed suggests that this amount would be minimal, and entirely insufficient to account for the high rates observed.

Summary

A method is described for measuring the rate of water evaporation from selected areas of skin without altering markedly the humidity of the air to which it is exposed. Air is circulated alternately through a capsule attached to the skin and an absorber containing a saturated solution of a salt giving the desired vapor pressure. The gain in weight of the absorber indicates the evaporation from the skin. A supplementary "maintenance" circuit is used to keep up air flow through capsules when they are not subject to measurement.

Examples are given of results obtained by the use of this apparatus on cows under hot conditions. Different areas give different rates, especially under the less hot conditions. The rate of evaporation is increased with the hotter conditions. No significant differences are found

between Jersey and Sindhi-Jersey crossbred cows for areas on the forechest and paunch. The rates for these areas under severely hot conditions (105° F., and 34 mmHg vapor pressure) reach 660 gm./sq. m., hr.

The same technique applied to rabbits under the same hot conditions revealed virtually no evaporation.

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THE EFFECT OF ALFALFA ASH UPON THE DIGESTIBILITY OF PRAIRIE HAY BY SHEEP [1]

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THE work of Burroughs *et al.* (1950) with cattle showed that the addition of alfalfa ash promoted a greater digestibility of a ration containing corn cobs. These workers postulated that the addition of alfalfa ash promoted a more active microflora in the rumen, and that this in turn resulted in a more efficient utilization of the crude fiber and other constituents in the corn cob ration. Swift *et al.* (1951) working with sheep found that when alfalfa ash was added to a corn cob ration more methane was produced, indicating greater microfloral activity. The net effect of the added ash was, however, an increase in the amount of feed energy made available to the host. Chappel (1952), using a corn cob basal ration of somewhat different composition confirmed the positive effects of alfalfa ash in sheep and further reported that a synthetic alfalfa ash, compounded from inorganic salts on the basis of the mineral composition of natural alfalfa ash, also caused an increased digestibility of the basal ration. In similar studies, Klosterman *et al.* (1953) showed that alfalfa meal, alfalfa ash, and a trace mineral mixture containing iron, manganese, copper, zinc and cobalt improved for steers a fattening ration containing poor quality timothy hay. In a later study, Bentley and Moxon (1952) reported that the poor quality timothy hay was low in cobalt and that either alfalfa ash or a cobalt-containing salt mixture corrected this deficiency.

A large amount of the roughage used in the central plains region consists of grasses native to the area. When cut for hay in the later stages of growth they contain substantial amounts of materials resistant to digestion. It seemed desirable, therefore, to study the effect of alfalfa ash upon the digestibility of prairie hay as a typical example of such a forage.

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Experimental Procedure

First Digestibility Trial

The rations were compounded in such way to test the effect of a complete mineral mixture and alfalfa ash upon the digestibility of a basal ration containing a large amount of coarsely-ground prairie hay. The composition and daily consumption of the basal ration (ration 1) by each sheep was: prairie hay, 360; ground yellow corn, 320; corn gluten meal, 120; di-calcium phosphate, 10; sodium chloride, 5; and cod-liver oil, 1 (all in grams). Ration 2 consisted of the basal ration minus sodium chloride, plus 12 grams daily of the following mineral mixture: sodium chloride, 900; manganese sulfate, 1; magnesium carbonate, 300; zinc chloride, 1; potassium chloride, 200; ferrous sulfate, 1.5; and copper sulfate, 3.5 grams. Alfalfa ash, which was

TABLE 1. CHEMICAL COMPOSITION OF THE BASAL RATIONS (DRY MATTER BASIS)

Basal Ration	Dry Matter	Crude Protein	Ether Extract	Crude Fiber	NFE	Ash	Organic Matter	Energy
	%	%	%	%	%	%	%	cal. per gm.
First digestibility trial	92.3	12.4	1.3	16.9	63.1	6.3	86.0	....
Second digestibility trial	87.6	12.2	8.5	15.1	56.0	8.2	92.9	3551

prepared by burning alfalfa hay in an open tank followed by further ashing in a muffle furnace at 600° C., was supplied in ration 3 at the level of 40 grams per day. The chemical composition of the basal ration is shown in table 1.

Western wether lambs were the experimental subjects. Two weeks prior to their being placed on their respective rations, each lamb was drenched with a preparation containing phenothiazine. Twelve lambs were randomly divided into three equal groups and each group was placed in a large box stall. The animals were fed their respective rations in individual stanchions and when not eating were allowed freedom of the stall with free access to water. Collection of the feces was made by means of a light harness and bag similar to the type described by Garrigus (1939). The feces were collected once daily, weighed, and aliquoted for analysis. The samples were kept in tightly sealed jars under refrigeration until analyzed.

Two weeks prior to the beginning of the experiment all experimental animals were given the same ration. They were then placed on their

respective rations for a 7-day preliminary period which was followed immediately by a series of 6 consecutive 3-day collection periods. Analysis of the feed and excreta were conducted according to the methods of the AOAC (1950). The gross energy was determined in an Emerson fuel calorimeter equipped with an adiabatic chamber. The data were analyzed statistically by analysis of variance as described by Snedecor (1946).

Second Digestibility Trial

A semi-purified basal diet of the following composition was used in this trial: prairie hay, 50.00; corn oil, 5.00; cerelose (corn sugar), 38.05; urea (Two-sixty-two), 3.00 di-calcium phospate, 3.00, salt, 0.50; sodium sulfate, 0.35; and vitamin A-D oil (3000 I.U. of A and 600 I.U. of D per gram) 0.10 (all in percent). The chemical composition of the ration is shown in table 1.

The prairie hay was ground in a hammer mill through a 7/16″ screen, mixed with the other ingredients in a vertical mixer, and stored in a cool, dry place until used.

Twenty western wether lambs were used in this experiment. They were drenched with a phenothiazine preparation three weeks before starting on the test. During this period the animals were individually-fed the basal ration to determine their average daily consumption of feed. At the end of this phase the animals were divided in a randomized manner into four equal groups. Each group of five were placed in a large box stall and fed their respective rations in individual stanchions for a 10-day preliminary period followed by a 10-day collection period. Two groups received 510 grams of the basal ration while the other two groups received 510 grams of the basal plus 28 grams of alfalfa ash daily. At the end of this trial the animals were switched with respect to previous treatments and the trial was repeated. In this second phase, only the preliminary and collection periods were conducted and the intake of feed per sheep was the same as in the first period.

Other details were the same as in the first trial except a total collection of the feces was made. The daily collection was transferred to an oven which was equipped with a blower and dried at a low temperature (55–60° C.) for approximately 24 hours. At the end of the collection period, the total collection was mixed, ground, and sampled for analysis.

Results and Discussion

First Digestibility Trial

The percentages of organic matter digested by the lambs during six consecutive 3-day collection periods are summarized in table 2.

Statistical analysis of the data revealed that there were no differences at the 0.05 level of probability when the three treatments were considered. This was true for the average of the six periods as well as for any individual 3-day period.

The purpose of the consecutive 3-day collection periods was to determine if any adjustment period was required for the microorganisms

TABLE 2. THE EFFECT OF MINERAL SUPPLEMENTS ON THE DIGESTIBILITY OF ORGANIC MATTER IN RATIONS CONTAINING PRAIRIE HAY

Ration Number	Percentage of Organic Matter Digested						
	3-Day Collection Period Number						Average of Six 3-Day Period
	1	2	3	4	5	6	
	%	%	%	%	%	%	%
1	63.5	71.7	71.0	69.1	68.5	66.9	69.3
2	68.9	69.2	70.0	68.0	67.5	64.5	68.0
3	68.9	70.8	71.2	69.3	71.0	69.0	70.0

of the rumen to become adjusted to the change in ration. If an increase in the digestibility of organic matter can be considered to reflect the course of such an adjustment period, these data strongly indicate that if any such adjustment occurred it must have taken place during the 7-day preliminary period.

The variation in digestion coefficients of any ration constituent between animals receiving the same ration was great when any 3-day collection period was considered. However, when the averages of three or more of these were combined to make a longer collection period, the variation between animals became smaller, indicating that a 3-day collection period is not of sufficient length for digestion trials with sheep.

The digestion of ration constituents for the average of the first three 3-day collection periods appears in table 3. As there seemed to be no definite trend in digestion of organic matter, the feces of the final three collection periods were not subjected to complete proximate analysis.

The percentages of protein digested were 71.4, 69.9 and 71.8 for the control, complete mineral mixture and alfalfa ash rations, respectively. It is of interest to note that the addition of the supplements appeared to decrease the digestion of crude fiber. These differences are small, however, and are not significant statistically. This is also true in the case of organic matter.

TABLE 3. THE EFFECT OF MINERAL SUPPLEMENTS UPON THE DIGESTION OF COMPONENTS OF RATIONS CONTAINING PRAIRIE HAY

Ration and Period	Organic Matter	Crude Protein	Ether Extract	Crude Fiber	NFE
	%	%	%	%	%
Ration 1					
Period 1	68.5	68.6	5.1	46.9	75.6
Period 2	71.7	74.3	22.6	50.1	77.6
Period 3	71.0	71.1	25.2	50.7	77.3
Average	70.4	71.4	17.6	49.6	76.8
Ration 2					
Period 1	68.9	69.5	9.7	47.3	76.1
Period 2	69.2	69.8	26.6	46.2	76.1
Period 3	70.0	70.5	36.6	49.2	75.9
Average	69.4	69.9	23.6	47.6	76.0
Ration 3					
Period 1	68.9	70.2	18.6	43.2	76.5
Period 2	70.8	72.9	40.1	48.6	77.0
Period 3	71.2	72.1	36.8	51.0	76.9
Average	70.4	71.8	31.8	47.6	76.8

Under these conditions neither the addition of a complete mineral mixture nor of alfalfa ash improved the apparent digestibility of the prairie hay basal ration.

Second Digestibility Trial

The results of the second trial as summarized in table 4. Each digestion coefficient in this table represents the average of twenty sheep receiving a semi-purified diet in which practically all of the minerals other than sodium, chlorine, calcium and phosphorus were supplied by the prairie hay. The differences in digestion coefficients between the two treatments were small for each ration constituent. Statistical analysis of these data showed the differences were not significant at the 0.05 level of probability.

These data, obtained from an experiment which subjected prairie hay to a more critical test with respect to its mineral content, confirmed the results of the first digestion trial in which it was also found that alfalfa ash failed to promote a greater digestibility of the prairie hay basal ration.

It is interesting to consider these results on the basis of the chemical analysis of these two forages as reported by Beeson (1941) and Glendenning *et al.* (1952). The chemical analysis reveals that alfalfa hay contains more calcium, phosphorus, potassium, chlorine and mag-

TABLE 4. THE EFFECT OF ALFALFA ASH UPON THE DIGESTIBILITY OF COMPONENTS OF RATIONS CONTAINING PRAIRIE HAY

Ration	Dry Matter	Crude Protein	Ether Extract	Crude Fiber	NFE	Organic Matter	Energy
	%	%	%	%	%	%	%
Basal	67.1	69.2	88.2	47.2	74.2	70.6	63.9
Basal + alfalfa ash	65.3[1]	68.0	90.0	48.5	73.6	70.2	63.0

[1] Assumed that the alfalfa ash was 100 percent dry matter.

nesium than prairie hay and that the two are approximately equal in their content of trace minerals. The total ash content of the prairie hay is about 7.2 percent and that of alfalfa hay as reported by Morrison (1948) is approximately 8.2 percent. Many workers have shown that alfalfa ash improves digestibility of corn cobs, and Tillman *et al.* (1953) have shown that it also improves digestibility of cottonseed hulls. The total ash contents of these two roughages are approximately 1.6 and 2.6 percent, respectively. If the total ash and trace mineral contents are major considerations in the rationalization of why alfalfa ash increases the digestibility of some roughages and is of no value in others we should expect no increase in the utilization of prairie hay by the addition of alfalfa ash. The extreme variation of trace mineral contents of forages grown on different soil types as pointed by Beeson (1941) should be considered, however, before this view can be taken too literally.

The work of Kleiber *et al.* (1936) with phosphorus, Woodman and Evans (1930) with calcium and phosphorus, and Becker and Smith (1949) with cobalt indicates that a deficiency of a mineral element does not affect the digestibility of ration constituents. It must be pointed out, however, that the cobalt deficient lambs of Becker and Smith were receiving less feed than the supplemented group. The

works of Burroughs *et al.* (1950), Swift *et al.* (1952) and Chappel (1952) with corn cobs show without doubt that alfalfa ash increased the digestibility of this type of ration. In the light of this later work, an increase in the digestibility of ration constituents would be expected to accompany any condition that would cause an increased activity of the microorganisms. It can be seen from the data of these two trials that neither the addition of a complete mineral mixture nor of alfalfa ash increased the digestibility of a prairie hay basal ration by sheep.

Summary

Two digestibility trials involving 52 sheep were conducted to study the effect of supplementing a ration containing low quality prairie hay with a complete mineral mixture or alfalfa ash. In the first trial, the basal ration contained natural feedstuffs in addition to the hay. In the second, a semi-purified diet was used in which the prairie hay was the only natural feedstuff. In both trials neither alfalfa ash nor a complete mineral mixture was found to improve the apparent digestibility of the ration or any of its proximate components. In these studies, it appeared that a three-day collection period was not of sufficient length to obtain an accurate measure of the apparent digestibility of this type of ration by sheep.

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THE EFFECT OF STILBESTROL UPON LAMB PERFORMANCE IN THE FEEDLOT [1]

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EXPERIMENTAL tests have shown that subcutaneous implantations of stilbestrol pellets in feeder lambs will increase rate of gain and efficiency of feed utilization (Andrews *et al.*, 1949, 1952, and 1953; R. M. Jordan, 1950 and 1953; P. S. Jordan *et al.*, 1952; O'Mary *et al.*, 1951; Pope *et al.*, 1950; Whitehair, 1953). A reduction in carcass quality was generally shown in these studies. No death losses or visible harmful effects resulting from the use of stilbestrol have been reported in the experimental lambs included in these studies, although R. M. Jordan (1953) refers to heavy losses in a commercial feed lot from a blockage of the urinary tract and prolapse of the rectum in a group of 8,000 feeder lambs given a 12 mg. pellet of stilbestrol. Jordan also refers to a 10 percent death loss from a prolapse of the rectum in another group of 3,500 feeder lambs that had received stilbestrol implants. No control groups of similar untreated lambs were available for comparison. Bennetts (1946 and 1947) and Bennetts *et al.* (1946) described changes occurring in the secondary sex organs of wethers grazing on subterranean clover in western Australia and produced these same changes clinically with large doses of stilbestrol. O'Mary *et al.* described changes occurring in the ampullae and seminal vesicles of wethers given stilbestrol implants.

The studies here reported were undertaken to determine the influence of stilbestrol upon rate of gain, feedlot efficiency, and carcass grades of lambs fed various rations commonly used in Kansas. When death losses were observed to be higher in the groups which were treated with stilbestrol, detailed studies were made of the uro-genital systems of the treated and untreated lambs in an effort to learn more about the cause of the losses.

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Materials and Methods

Five hundred and seventeen whiteface fine wool feeder lambs from New Mexico were fed in 11 lots, each lot containing 43 wethers and four ewe lambs. The tests were conducted at the Kansas Branch Experimental Station at Garden City in western Kansas from November 7, 1952, to February 27, 1953. Average initial weight of the lambs was 67 lb. Final lot weights (per lamb) at the end of the 112-day feeding period ranged from 95 to 120 lb. The experimental rations compared whole milo grain, rolled milo, and ground milo. These were all fed with ground sorghum stover plus a protein supplement and supplemental salt and limestone. The roughage comparisons included: (1) sorghum stover, (2) alfalfa hay, (3) one-half alfalfa hay and one-half sorghum stover (with and without a protein supplement), and (4) sorghum stover in combination with sorghum silage.

One lot of lambs received no supplemental salt; another lot received Aurofac 2A with the basal or standard ration of ground sorghum stover, whole milo grain, soybean pellets, ground limestone, and salt. At the start of the test all the lambs in one lot receiving the basal ration were each given a 15 mg. stilbestrol pellet implanted subcutaneously in the region of the lower jaw. One lot of lambs was pastured for most of the feeding period on sorghum stubble supplemented with a small amount of alfalfa hay.

One-half of the lambs in all lots, except the one in which all lambs received stilbestrol, were given 15 mg. stilbestrol pellets at the beginning of the feeding period. One-half of the lambs in the various lots were vaccinated against overeating disease. Care was taken to provide vaccination for one-half of the stilbestrol treated lambs, leaving the remaining one-half unvaccinated.

Approximately 50 percent of the stilbestrol treated lambs each received a second pellet containing 15 mg. of stilbestrol after they had been on feed for 70 days.

At the conclusion of the experimental feeding period on February 27, 1953, a packer buyer selected all lambs grading choice or better. The selected lambs were slaughtered in a Wichita, Kansas, packing house and individual carcass grades and weights were obtained. The remaining lambs were shorn and given a ration of alfalfa hay and sorghum grain until they were slaughtered on April 21, 1953. In addition to slaughter data, uro-genital systems of stilbestrol treated and untreated lambs were recovered during the slaughtering process in the packing plant. The following measurements were taken: length

and width of the seminal vesicles; length and width of the bladders; diameter of the ampullae; diameter of the urethra and surrounding prostate gland; and the diameter of the bulbo-urethral or Cowper's glands. Additional lambs were brought to the college at Manhattan where further observations and studies were made.

During the summer of 1953 a small group of lambs included in the feeding tests at Manhattan were given pellet implants of either 7.5 or 15 mg. of stilbestrol at the beginning of a 68-day feeding period. They were slaughtered in the college meats laboratory at the end of the tests and comparisons were made with untreated lambs in the same tests.

Results and Discussion

Average daily gains of the variously treated lambs (the four ewe lambs from each lot were excluded from the analyses) are presented in table 1. Lambs receiving either one or two pellets of stilbestrol made significantly greater gains than lambs receiving no stilbestrol. Differences in rate of gain of lambs receiving one pellet and two pellets were non-significant. These results are in agreement with the results of the work at other stations previously reviewed. Vaccination for overeating disease did not affect rate of gain significantly.

Approximately one-third of the lambs was graded as choice or better by a packer buyer at the end of the test. A slightly smaller percentage of the lambs given stilbestrol was selected compared with those given no implants. Seven lambs died during the initial feeding period—two from enterotoxemia and five with symptoms similar to those produced by urinary calculi. Both lambs dying from enterotoxemia had been vaccinated. Four of the five lambs dying with urinary calculi symptoms and one of the two dying from overeating had received two implants of stilbestrol. At the time of Lamb Feeders' Day, eight days following the conclusion of the trials, additional lambs were showing stress during urination and several were swollen visibly in the perineal region. A local feeder was present and noted that the affected lambs appeared similar to some he had observed in a group of 3,000 that had been given stilbestrol implants. These lambs were Texas feeders weighing approximately 60 lb. and were self-fed alfalfa hay and corn. Losses resulting presumably from rectal prolapse and abnormal swellings in the perineal region were encountered about 60 days following stilbestrol pellet implantation and continued until the lambs were marketed.

TABLE 1. AVERAGE DAILY GAINS MADE BY WETHER LAMBS

Lot Number	1	2	3	4	5	6	7	8	9	10	11	Average
Ration	Basal [1]	Basal (Ground Milo)	Basal (Rolled Milo)	Alfalfa Milo Grain Salt	½ Alfalfa ½ Stover Milo Grain Lime-stone Salt	½ Alfalfa ½ Stover Milo Grain Protein Lime-stone Salt	Silage Stover Milo Grain Protein Lime-stone Salt	Basal Ration Plus Aurofac 2A	Milo Stubble Alfalfa Salt	Basal All Lambs Given Stilbestrol	Basal No Salt	
No treatment	.295 [2]	.257	.330	.404	.350	.375	.289	.324	.348		.179	.315
Vaccinated	.291	.282	.355	.408	.369	.362	.291	.292	.343		.238	.323
One pellet of stilbestrol	.325	.512	.353	.498	.478	.518	.369	.365	.456	.324	.285	.408
One pellet plus vaccine	.419	.335	.404	.580	.405	.451	.402	.389	.424	.390	.284	.408
Two pellets stilbestrol	.358	.388	.380	.445	.488	.468	.371	.349	.489	.371	.203	.392
Two pellets plus vaccine	.328	.383	.428	.546	.542	.514	.397	.375	.445	.391	.236	.417
Average	.336	.360	.375	.480	.439	.448	.353	.349	.418	.369	.238	

[1] Whole sorghum grain, ground sorghum stover, soybean pellets, ground limestone, and salt.
[2] Pound.

Approximately seven percent of the lambs were described as having been affected in notes made of visual observations.

Ten of the lambs from the Garden City study were taken to Manhattan and slaughtered in the college meats laboratory. Difficulty was encountered in removing the pelts from the stilbestrol treated lambs; the carcasses had a watery, slimy appearance, and stilbestrol treated lambs dressed one to five percent lower than the untreated lambs. An examination of the uro-genital systems revealed that the treated lambs had much larger accessory reproductive organs.

Approximately 300 lambs remained at Garden City after the termination of the experimental feeding trials. These were shorn and fed alfalfa hay and corn.

Eight lambs died during the period from February 27 to the date of slaughter on April 21. All eight lambs had received two implants of stilbestrol and death was caused by rectal prolapse or conditions resulting from excessive swelling in the perineal region. Virtually every lamb receiving stilbestrol, either one or two pellets, exhibited symptoms which could be detected by careful visual examination. The prepuces of the treated lambs were slightly irritated and enlarged. Discomfort was apparent at the time of urination, and most of the lambs showed some swelling in the perineal region. Enlargement of the Cowper's glands in the treated lambs could be detected by rectal palpation.

A summary of the measurements taken on uro-genital systems from approximately 70 lambs receiving two pellets of stilbestrol, 80 lambs receiving one pellet, and 60 lambs receiving no stilbestrol, is shown in table 2. Significant differences between untreated lambs and those receiving one stilbestrol implant were shown in length and width of seminal vesicles, length and width of bladder, diameter of ampullae, diameter of urethra and prostate, and diameter of the Cowper's glands. Significant differences between lambs receiving one and two implants were shown in length of seminal vesicles, diameter of ampullae, diameter of urethra and prostate, and diameter of the Cowper's glands.

Slaughter data from the lambs fed after the conclusion of the trial showed highest carcass values in the control lambs, next highest in the group receiving one implant and lowest in the group receiving two implants.

Measurements of the uro-genital systems of lambs treated during the summer of 1953 were similar to those found in the Garden City study.

TABLE 2. MEASUREMENTS OF URO-GENITAL ORGANS OF UNTREATED WETHER LAMBS AND THOSE RECEIVING ONE OR TWO 15 MILLIGRAM PELLETS OF STILBESTROL (MM.)

Treatment	Seminal Vesicles		Bladder		Ampulla Diameter	Urethra and Prostate Diameter	Cowper's Diameter
	Length	Width	Length	Width			
Control	10.9	5.0	38.2	20.7	3.5	10.84	8.73
One 15 mg. stilbestrol pellet	22.0	14.8	57.7	33.7	5.2	16.63	15.51
Two 15 mg. stilbestrol pellets	26.9	15.6	55.9	34.9	7.0	20.51	21.77
LSMD .05 level	2.61	1.84	4.60	2.69	0.65	1.05	1.39
LSMD .01 level	3.48	2.44	6.12	3.58	0.87	1.38	1.84

Data on changes occurring in the females in the two studies were too limited to warrant conclusions concerning the effect of stilbestrol upon the female reproductive organs.

The particular effects upon the uro-genital systems of wethers found in these studies have not been noted by other workers in the United States but are similar to those reported by the Australian workers studying the effect of estrogenic materials in subterranean clover upon the reproductive glands of wethers. Infection and necrotic lesions were found in the accessory reproductive organs of the lambs in this study and are similar to those described by Bennetts. He believes that debris from these infections are largely responsible for a blockage of the urinary tract and the production of symptoms similar to those produced by urinary calculi. Post mortem examination of some of the lambs showing excessive swelling in the rectal region in the Garden City trials revealed the development of a cul-de-sac filled with urine virtually identical to those described by Bennetts and believed by him to be an outpocketing of the Cowper's glands. Prolapse of the rectum was not a particular symptom of the affected Australian wether lambs running on subterranean clover pasture, but its high incidence in the Garden City lambs as well as in several commercial flocks that were treated with stilbestrol can probably be explained as resulting from the straining caused by difficulty in urinating.

Summary

Subcutaneous implantation of a 15 mg. pellet of stilbestrol at the beginning of the feeding period increased significantly the rate of gain in lambs being fattened on various Kansas rations. Lambs given a second implant after 70 days of feeding did not gain any faster than those given only one implant. Carcass grades and dressing percentages were slightly lower in the treated lambs than in the untreated ones.

Twelve lambs were lost (of 517 in the experimental tests at Garden City) from prolapse of the rectum and from excessive swelling and inflammation in the rectal or perineal region, or showing symptoms similar to those produced by urinary calculi. All 12 lambs dying from these causes had each received two implants of 15 mg. of stilbestrol. Virtually all the treated lambs, both those receiving one pellet and those receiving two, had preputial swelling and indicated distress during urination. Many of the treated lambs showed visible swelling in the perineal region.

Measurements taken of the uro-genital systems of treated and untreated lambs revealed enlarged seminal vesicles, bladder, ampullae, urethra, prostate gland, and bulbo-urethral glands in the treated lambs. The most noticeable changes were seen in the Cowper's glands where in severe cases, a cul-de-sac filled with urine was developed.

A possible explanation of the symptoms of urinary calculi and rectal prolapse in the treated lamb is offered.

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COMPARING HIGH-, MEDIUM-HIGH-, AND LOW-PROTEIN CORN FOR FATTENING LAMBS [1, 2, 3]

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MANY studies have been made of factors affecting the composition of corn. Stubblefield and DeTurk (1940) studied the effect of crop yield, soil type and treatment, and seasonal conditions on the composition of corn and other grains. Hamilton *et al.* (1951) found a variation of 40 percent in protein content (10.4 percent to 7.5 percent on the dry basis) of the same varieties of corn grown during the same season under the best conditions of soil and crop management and under the worst conditions imposed.

Hopkins *et al.* (1903) first demonstrated that changes in the protein content of corn induced by selective breeding are related to changes in the proportions of the various anatomical parts of the kernel. Hansen *et al.* (1946) showed a straight line relationship between total protein and zein content. Frey (1951) showed that as the protein percentage of corn increased tryptophan (absent in zein) made up a decreased proportion of the total protein. Cannon *et al.* (1952) reported in detail on the chemical composition of corn.

Plant breeders have produced strains of corn that contain as much as 20 percent crude protein in the grain on a dry basis (Woodworth *et al.*, 1952). Although yield and percent protein of the grain appear to be inversely related, there are a few hybrids of high protein content which yield very well.

Efforts have been made to determine the nutritive value of high-protein corn for monogastric animals (Dobbins *et al.*, 1950; Eggert *et al.* 1951, 1953; Mitchell *et al.*, 1952). Data indicate that for monogastric animals the protein of high-protein corn may be of lower biological value than that of low-protein corn. Ruminants, however, are likely to utilize the protein from high-protein corn satisfactorily,

[1] This paper is part of a thesis submitted by the senior author to the Graduate College, University of Illinois, in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Animal Science.

[2] Grateful acknowledgment is made to Funk Brothers Seed Company, Bloomington, Illinois, for furnishing the corns used in the experiment and to Dr. J. L. Krider, Central Soya Company, Fort Wayne, Indiana, for arranging for the preparation of the timothy hay-molasses mixture.

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since for them the biological values of most proteins are similar (Johnson *et al.*, 1944). In a feeding experiment at the University of Illinois (1952), yearling steers fed high-protein corn required 82 pounds less shelled corn and 263 pounds less corn silage per 100 pounds gain than similar steers fed low-protein corn.

The present experiment was conducted to determine the comparative value of two high-protein corns and a low-protein corn for fattening lambs, body-weight gains, wool growth, and carcass grades being used as criteria for comparison.

Experimental

Thirty black-faced Western lambs were assigned to trios on the basis of size, sex, type, and character of wool. The lambs were housed in a shed open to the south, and given access to an outside dry lot. They were trio-fed (equal feed) in individual feeding crates twice daily all they would clean up in 30 minutes. The feeding period began February 9, 1950, and extended to May 3, when the last lambs were slaughtered.

At the end of the sixth week a small patch of wool was clipped down to the skin from an area approximately 6 in. by 8 in. on the right thigh of each lamb.[5] Subsequent wool growth in the clipped area was used in determining the effect of the three experimental rations. Four weeks later a sample 4.0 cm. wide by approximately 12 cm. long was clipped from the new wool growth on each lamb. Wool was kept in plastic bags until it was washed with neutral soap flakes in warm distilled water then rinsed three times in distilled water. Each clean wool sample was dried for 5 hours in an oven at 105° C. and weighed.

Lambs were weighed on February 9 and each two weeks thereafter. Carcass weights and dressing percentages were obtained.

The lambs were fed a ration composed of shelled yellow corn and a roughage made up of ground timothy hay, 80 percent, and black-strap molasses, 20 percent. Protein content of the air-dry corns was as follows: high-protein, 13.20 percent; medium-high-protein, 11.05 percent; and low-protein, 7.72 percent. Protein content of the timothy-molasses roughage was 6.09 percent. These percentage values on a dry-weight basis were 14.9, 12.62, 9.12 and 7.00, respectively. The ration at first was high in roughage and low in grain, and was gradually changed until the lambs were consuming approximately equal quantities of roughage and grain.

[5] Oster small animal clipper, Model A2 size 40 blade.

Water was furnished *ad libitum,* and a mineral mixture composed of dicalcium phosphate two parts and trace mineralized salt one part was before the lambs at all times. Wood shavings were used for bedding.

Results and Discussion

In table 1 is shown average weight gains, feed consumption, dressing percentages, and wool growth of the lambs.

TABLE 1. RESULTS OF FEEDING HIGH-, MEDIUM-HIGH, AND LOW-PROTEIN CORN[1] TO FATTENING LAMBS

Item	High-Protein Corn Ration	Medium-High-Protein Corn Ration	Low-Protein Corn Ration
Number lambs started on test	10	10	10
Number lambs completing test[2]	8	8	8
Average initial weight, lb.	79.1	78.8	78.5
Average final weight, lb.	96.8	96.6	90.9
Average gain, lb.	17.7**	17.8**	12.4
Average daily gain, lb.	0.25	0.25	0.18
Feed per pound gain, lb.	9.19	9.16	13.96
Corn, lb.	4.21	4.20	6.82**
Timothy hay, lb.	4.98	4.96	7.14**
Average dressing percent	46.9	47.1	47.7
Wool growth per 100 cm., gm.	1.56*	1.54*	1.29

[1] Protein content on an air-dry basis was 13.2, 11.06, and 7.72 percent for the high-, medium-high-, and low-protein corn, respectively. Roughage was a mixture of approximately 80 percent ground timothy hay and 20 percent blackstrap molasses and contained 6.09 percent crude protein.

[2] One lamb died during the test. (Autopsy failed to determine cause of death). Another especially unthrifty lamb was removed from the experiment shortly after the test began. Since lambs were being fed equal feed, these losses necessitated removal of both of their trio mates in each case.

* Significant at the 5 percent level of probability, low-protein corn versus either of the higher protein corns.

** Significant at the 1 percent level of probability, low-protein corn versus either of the higher protein corns.

Lambs fed high-protein corn were easier to put on feed and stayed on feed better than those on low-protein corn. It was noted that the lambs on low-protein corn determined the level of feed consumption for the trio.

Lambs fed either of the high-protein corns made greater gains than those fed the low-protein corn. There was no significant difference between gains made by the lambs fed the high-protein corns. Work by Willman *et al.* (1947) indicated that a 10.8 percent crude protein ration is adequate for fattening lambs. It is possible that the Illinois lambs, gaining slowly, did not need additional protein.

Wool growth was greater by the lambs fed high-protein corn than by those fed low-protein corn. There was no significant difference in growth of wool between lambs on the two high-protein corns.

The average dressing percentage was somewhat higher in the case of lambs fed low-protein corn, but the difference was not statistically significant. Four lambs graded choice in the low-protein corn lot compared with three in the medium-high-protein corn lot and one in the high-protein corn lot. The rest of the carcasses graded lower.

Summary

Thirty black-faced Western lambs were trio fed (equal feed) for 70 days on corn-timothy hay-molasses rations to compare the feeding value of high-, medium-high-, and low-protein corn (13.2, 11.03, and 7.72 percent crude protein). Body gains, wool growth, dressing percentage and carcass grades were compared. Lambs fed both high- and medium-high-protein corn made significantly greater gains (1 percent level) and produced significantly more wool (5 percent level) than lambs fed low-protein corn. No significant differences were observed between gains or wool produced by lambs on the medium-high- and high-protein corn.

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THYROPROTEIN FOR LACTATING EWES AND ITS EFFECT ON LAMB WEIGHTS [1, 2]

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BLAXTER, Reineke, Crampton and Petersen (1949) cited many instances in which the use of thyroidal materials increased the milk production of lactating dairy cattle. They concluded that the increase in milk production, which was also accompanied by an increase in fat percentage, was a result of a stimulation of the body metabolism of the animal and that increased nutrient intake was necessary if losses in body weight were to be avoided. Reineke (1943) reported an increase of from 0 to 50% in milk secretion following the feeding of iodinated protein. Newman *et al.* (1950) reported a significant increase in weights of lambs that were nursing ewes that had received one gram of thyroprotein (protamone) for 100 pounds of body weight. Greater loss of body weight was evident in the ewes fed thyroprotein.

The purpose of this investigation was to gather additional data relative to the response of lactating ewes to thyroprotein and to determine its effect on early lamb production.

Procedure

Three trials were conducted, one each in 1950, 1952 and 1953. In all three years Hampshire ewes that were suckling lambs were used as the test animals. The ewes were divided into two groups on the basis of their age, weight of their lambs, and whether the ewe was nursing a single or a pair of lambs. The ewes were fed a mixture of alfalfa-brome hay of good quality, a liberal feed of grain and .2 lb. of soybean meal per ewe daily. In the first trial 500 gm. of thyroprotein (protamone) was mixed with 100 lb. of soybean meal and .2 lb. of this mixture was fed per ewe thus providing one gm. of thyroprotein per ewe daily. In the second trial the amount of thyroprotein was increased so that each ewe received 1½ gm. per ewe daily. In the third trial the amount of thyroprotein was fed at a level so as to provide each ewe with two gm. a day.

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[2] Thyroprotein donated through courtesy of Cerophyl Laboratories, Kansas City, Missouri.

The lambs were creep fed in all three trials. It was recognized that liberal feeding of the lambs would tend to "mask" the differences between the two groups. However, creep feeding is an accepted program for producing maximum gains in early lambs. Therefore, if thyroprotein feeding of ewes is to be practiced to increase milk yield and ultimately lamb growth, creep feeding would also be a part of the feeding program. An effort was made to prevent the young lambs from eating any of the grain mixture that was being fed the ewes. However, in the first trial, the young lambs did eat some grain out

TABLE 1. EFFECT OF THYROPROTEIN ON BODY WEIGHT OF LACTATING EWES

Item	1950		1952		1953	
	Control	Treated	Control	Treated	Control	Treated
	1	2	1	2	1	2
Number of ewes	10	10	10	10	9	8
Days fed	57	57	51	51	54	54
Amount thyroprotein fed per ewe daily, gm.	0	1	0	1.50	0	2
Av. initial wt., lb.	156.6	154.8	161.2	158.0	163.4	177.2
Av. final wt., lb.	146.7	142.1	154.1	146.9	156.7	163.4
Gain per ewe, lb.	−9.9	−12.7	−7.1	−12.1	−6.7	−13.8
Death loss	0	0	0	0	0	0
Daily feed consumption						
Grain	1.2	1.2	1.5	1.5	1.2	1.2
Hay	3.4	3.4	3.5	3.5	4.0	4.0
Protein	.2	.2	.2	.2	.2	.2

of the troughs provided for the ewes in spite of the fact that these grain troughs were elevated 2½ feet above the ground. In the second and third trials in order to prevent the lambs from consuming any of the grain that contained the thyroprotein it was necessary to feed the lambs in the creep first and lock them in before feeding the ewes their grain. Individual weights were taken of the ewes at approximately 28 day intervals and of the lambs every 14 days. The feeding of grain and thyroprotein was discontinued in all three trials at the time the ewes went to pasture.

Results

Ewe Data

The effects of thyroprotein on the body weight of the ewes during the three trials is shown in table 1.

During the first trial 1.2 lb. of grain and 3.4 lb. of hay were fed each ewe daily. At this level of feeding some hay was refused at each feeding in both lots although the treated ewes left less of their hay than the control group. In spite of this liberal feeding the control ewes lost 9.9 lb. and the ewes that received one gm. of thyroprotein lost 12.7 lb. During the second trial 1.5 lb. of grain and 3.5 lb. of hay were fed per ewe daily. This liberal grain and hay feeding, which resulted in refusal of a considerable amount of the hay, failed to prevent body loss during this lactation period. The control ewes lost 7.1 lb. and the ewes receiving 1½ gm. of thyroprotein lost 12.1 lb. In the third trial the control ewes lost 6.7 lb. and the ewes receiving 2 gm. of thyroprotein per ewe daily lost 13.8 lb. While the differences in weight losses during the three trials are not statistically significant there is a consistent pattern in all three trials showing that the ewes that were fed thyroprotein had a tendency to lose more body weight. Further, as the amount of thyroprotein fed per ewe daily increased the difference in the weight losses between the two groups also increased, with the least difference in weight losses resulting when 1 gm. of thyroprotein was fed per ewe and the greatest difference in weight loss resulting when 2 gm. of thyroprotein was fed per ewe.

Lamb Data

The effects of thyroprotein when fed to lactating ewes on the growth rate, feed intake and feed efficiency of the suckling lambs during the three trials is shown in table 2.

In the first trial the average daily rate of gain of the control lambs was .68 as compared to .71 lb. for the lambs suckling the ewes receiving 1 gm. of thyroprotein. This difference in the rate of gain between these two groups of lambs was not significant. The lambs in the treated group consumed approximately 16 percent more feed than the control lambs. This may be explained by the fact that they were consuming some of the grain fed to the ewes which contained thyroprotein which may have in turn increased their metabolism sufficiently to cause them to have a greater appetite. One of the serious problems in feeding thyroprotein to lactating ewes is that of preventing the lambs from eating thyroprotein supplemented feed when it is being fed to the ewes.

In the second trial both groups of lambs gained .81 lb. per lamb daily. During the trial the lambs were locked in the creep and had no opportunity to consume any grain that contained thyroprotein. Feed

consumption by the lambs in both groups was the same. In the third trial the control lambs outgained the lambs suckling the ewes treated with 2 gm. of thyroprotein (.70 lb. per lamb daily as compared to .66 per lamb daily in lot 2). Because the lambs in lot 2 gained slightly less but consumed the same amount of feed per lamb daily the feed required per 100 pounds of gain is slightly greater. While an effort

TABLE 2. EFFECT OF THYROPROTEIN WHEN FED TO LACTATING EWES ON LAMB GROWTH

Item	1950		1952		1953	
	Control	Treated	Control	Treated	Control	Treated
	1	2	1	2	1	2
Number of lambs	12	11	13	13	13	10
Days fed	57	57	51	51	54	54
Av. initial wt., lb.	36.9	36.0	32.7	29.4	24.0	23.0
Av. final wt., lb.	76.3	77.6	73.9	70.8	61.9	58.5
Gain per lamb, lb.	39.4	41.6	41.2	41.4	37.9	35.5
Av. daily gain, lb.	.68	.71	.81	.81	.70	.66
Death loss	0	0	0	0	0	0
Daily grain consumption, lb.	1.17	1.40	.86	.86	.52	.52
Grain per 100 lb. gain	172	195	106	105	75	80

was made to feed all the grain that the lambs would consume there was no difference in feed consumption between the two groups in the second and third trial. Lambs creep-fed and suckling ewes to whose ration 1 to 2 gm. of thyroprotein was added per ewe daily exhibited no greater growth rate than creep-fed lambs and suckling ewes which were not fed thyroprotein.

Summary

Three trials were conducted in which thyroprotein was fed to lactating ewes and the effect on the rate of gain of the nursing lambs studied. In all trials the feeding of thyroprotein to lactating ewes failed to increase the growth rate of the nursing lambs significantly. Greater loss of body weight during the feeding period occurred among the ewes receiving thyroprotein. Preventing the lambs from eating feed containing thyroprotein at the time the ewes are fed is a problem that limits its application.

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THE TOLERANCE OF SHEEP TO HIGH INTAKES OF SODIUM CHLORIDE

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THE use of sodium chloride to regulate the consumption of supplemental feed by range livestock has become widespread. Weir and Torell (1953), Riggs *et al.* (1953) and Cardon *et al.* (1953) have reported studies on this use of sodium chloride. A few livestockmen in California are also using salt to limit the concentrate consumption of growing and fattening cattle on pasture.

The paucity of information about the effect of high sodium chloride intakes on growing and fattening ruminants, the maximum consumption of salt compatible for optimum performance, and the effects of a consistently large intake of salt over a long period of time prompted the following investigation. This report presents the results of a study of ewe lambs that were fed four sodium chloride intakes from weaning through pregnancy and the early part of lactation.

Experimental

Forty head of crossbred ewes were divided at random into four lots of ten head each. They were fed rations with added sodium chloride levels of 0.5, 4.8, 9.1, and 13.1 percent for 253 days in dry lot. The figure of 4.8 percent was derived from estimates of the approximate percentages of salt consumed by range sheep whose concentrate intake was regulated by salt. The basal ration was composed of 85 percent ground alfalfa hay and 15 percent barley. Appropriate salt additions were mixed with the basal ration and the entire ration was pelleted. Feed and water were offered *ad libitum* during the entire experimental period.

Weight and feed records were not kept until all lots were on feed. This took nine days for Lot 4 (13.1 percent NaCl). Animals were not shrunk overnight before weighing because of possible harmful effects from the high salt rations. However, weights were taken before the morning feeding. During a 30-day period water consumption was measured. Evaporation losses were also measured and appropriate corrections made.

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When the ewes averaged 100 pounds, they were bred to four Suffolk rams. Each ram was placed with a group of ewes for two days and then rotated at two-day intervals to the other lots. Thus, a part of the ewes in each lot was bred to each ram. Rams were with the ewes for three complete estrous cycles. Lambing started March 1, 1953. Twenty-eight days after lambing, the ewes and lambs were removed from the experimental ration and continued on pasture. Records were kept on the ewes and lambs for 28 days after they were placed on pasture.

The ewes were bled four times during the experiment and determinations made of the hematocrit (packed red blood cell volume) and of blood serum albumin, sodium, and chloride. Samples of milk were obtained and analyzed for sodium, potassium, chloride, and protein. Albumin was separated from the blood serum by the method of Kingsley (1940) and determined as outlined by Greenberg (1929). Blood chlorides were determined by the method of Schales and Schales (1941); milk chlorides were determined as outlined by Sanders (1939). Sodium and potassium were determined directly on the blood serum by the use of a flame photometer; however, the milk was first wet ashed and then analyzed with the flame photometer for sodium and potassium.

Results and Discussion

Results for the first 71 days on the experimental rations are presented in table 1. This period began after the animals on 13.1 percent sodium chloride (Lot 4) were adjusted to this high salt intake and ended when breeding began. The average daily gain of all animals was excellent. Growing sheep can apparently consume an extremely high concentration of sodium chloride with little harmful effect, since the ewes on 13.1 percent sodium chloride made as rapid gains as the controls. It should be considered that some of the increases in weight of the high sodium chloride groups might be water; however, the hematocrits and serum albumin did not indicate any large accumulation of extracellular fluid. Unpublished data from other trials showed that overnight shrinks and dressing percentage of sheep on rations 2 and 3 were the same as the controls, but animals fed the Lot 4 ration did show a greater shrink.

The total feed consumptions, basal ration plus sodium chloride, of the lots on higher added amounts of salt were about equal to or greater than that of Lot 1. However, the lower consumptions of basal ration by the animals on the higher sodium chloride intakes account for the fact that basal ration required per 100 pounds of gain was some-

TABLE 1. GROWING AND FATTENING PERIOD, 71 DAYS

Items Compared	Lot 1 0.5% NaCl	Lot 2 4.8% NaCl	Lot 3 9.1% NaCl	Lot 4 13.1% NaCl
Ewes per lot	10	10	10	10
Av. initial wt., lb.	70	68	74	70
Av. final wt., lb.	102	104	105	104
Av. daily gain, lb.	0.47	0.52	0.45	0.48
Av. daily feed, basal ration, lb.	4.1	4.1	3.8	3.9
NaCl, lb.	.....	.20	.37	.58
Basal ration per 100 lbs. of gain, lb.	884	790	842	812
Av. daily water intake, lb.	14.7	25.4	32.6	45.8
Av. water intake per gram of added NaCl, ml.	.....	54.9	52.8	56.5

what lower for Lots 2, 3, and 4. Moisture analysis of the various rations showed no difference between lots. The sodium chloride intake per animal of Lots 2, 3, and 4 was 0.20 lb., 0.37 lb., and 0.58 lb., respectively.

The water intake as reported in table 1 was greatly increased by high sodium chloride intakes, emphasizing the fact that water supply is extremely important to animals with high sodium chloride intakes. Water intake per gram of added sodium chloride was calculated for the added sodium chloride of Lots 2, 3, and 4. This was done by making allowance for normal water requirements calculated from the data on Lot 1. All three lots on high sodium chloride intakes consumed about the same amount of water per gram of added salt.

Table 2 presents the analysis of the blood for certain constituents. These determinations were made four times during the experiment; since no significant difference was found between bleedings, an average is presented. Hematocrits and serum albumin determinations were made to obtain indications of any large accumulations of extra-cellular

TABLE 2. EWES BLOOD DATA

	Lot 1 0.5% NaCl	Lot 2 4.8% NaCl	Lot 3 9.1% NaCl	Lot 4 13.1% NaCl
Hematocrits, %	39.8	39.9	40.6	40.5
Serum Albumin, %	4.97	4.75	4.75	4.68
Serum Sodium, mg./100cc	328	330	331	337
Serum Chloride, mg./100cc	416	425*	433**	440**

* Indicates a significant difference from Lot 1 (controls).
** Indicates a highly significant difference from Lot 1 (controls).

fluid. There was no difference between lots in serum albumin and red blood cell volume, which would be some indication that at least there were no large accumulations of extra-cellular fluid. Serum sodium showed no change when larger amounts of sodium chloride were added to the ration. However, the chlorides in the serum increased with each added increment of sodium chloride. The blood chlorides were more

TABLE 3. PERFORMANCE OF EWES

	Days Per Period	Lot 1 0.5% NaCl	Lot 2 4.8% NaCl	Lot 3 9.1% NaCl	Lot 4 13.1% NaCl
Breeding period:	77				
Av. wt. gain, lb.		22	21	17	16
Av. final wt., lb.		124	125	122	119
Av. basal ration consumed, lb.		4.2	4.1	3.8	3.7
Av. NaCl consumed, lb.		.....	0.20	0.38	0.57
Gestation period: [1]	77				
Av. wt. gain, lb.		38	34	29	29
Av. final wt., lb.		162	159	151	148
Av. basal ration consumed, lb.		4.5	4.1	3.6	3.6
Av. NaCl consumed, lb.		.....	0.20	0.36	0.54
Lactation period: [2]	28				
Av. wt. loss, lb.		21	26	28	44**
Av. final wt., lb.		141	133	123	104
Av. basal ration consumed, lb.		4.8	4.8	4.4	3.7
Av. NaCl consumed, lb.		.....	0.24	0.44	0.57
Pasture period: [3]	28				
Av. wt. loss, lb.		14	15	10	6
Av. final wt., lb.		127	118	113	98
Fleece weight, lb.	..	8.8	9.9	9.0	9.6

** Indicates a highly significant difference from Lot 1 (controls).
[1] Includes only pregnant ewes.
[2] Includes only lactating ewes.
[3] Ewes and lambs were taken off of the experimental rations and placed on pasture.

sensitive than blood sodiums in response to additional high intakes of sodium chloride.

The performance of the ewes after the growing and fattening period was divided into four periods and is presented in table 3. During the breeding period the ewes consumed about the same quantities of feed and sodium chloride per day as they had in the growth period. There was some decrease in gain for the ewes fed 9.1 and 13.1 percent salt, but this was not statistically significant. The basal ration consumption

of the control ewes during the gestation period rose, while basal ration consumption and salt intakes of the salt groups remained constant. At the end of the gestation period the ewes on 9.1 and 13.1 percent sodium chloride were somewhat smaller than the controls.

Differences were noted during the lactation period. Ration consumption rose in all lots except for the ewes receiving the 13.1 percent salt ration. Weight losses were noted for all ewes. Lot 4 ewes showed a much greater loss of weight than the controls. This difference was statistically highly significant. After the animals were placed on pasture for the second 28 days of lactation, no great difference was observed between lots.

The performance data of the ewes from the time of breeding to the end of the lactation period indicates that 13.1 percent NaCl in the

TABLE 4. MILK ANALYSIS

	Lot 1 0.5% NaCl	Lot 2 4.8% NaCl	Lot 3 9.1% NaCl	Lot 4 13.1% NaCl
Sodium, mg./100cc	30.7	30.3	28.9	29.0
Potassium, mg./100cc	144.0	150.0	142.0	154.0
Chloride, mg./100cc	63.2	72.1*	77.3**	80.3**
Protein, %	5.15	5.40	5.02	5.22

* Indicates a significant difference from Lot 1 (controls).
** Indicates a highly significant difference from Lot 1 (controls).

ration is too high for optimum performance of the ewes, especially during the first 28 days of lactation. This intake of sodium chloride is a little greater than 0.5 lb. per day. While the loss in weight of the ewes on 9.1 percent NaCl was not significantly different from the controls, their final weight at the end of the first 28-day lactation period was 18 lb. less than the controls, a possible indication that this NaCl level is too high for optimum performance of gestating and lactating ewes.

Milk analysis, presented in table 4, showed no difference between groups in sodium, potassium, or protein. There was, however, a significant or highly significant increase in the chloride content with the addition of NaCl to the ration. This increase in chloride content is in agreement with the data of Weir and Miller (1953).

The lambing record is shown in table 5. There was no difference between Lots 1, 2, and 3 in number of ewes lambing or in the lambing percentage. Some decrease occurred in Lot 4; this can not be considered to be a real difference, however, because of the small num-

bers in the groups. The number of ewes that raised lambs and the number of lambs raised per ewe was somewhat lower in Lot 4. The gain of the lambs and the pounds of lamb produced per ewe, however, was about equal for all lots.

The weight of the wool produced by the ewes showed no difference between lots.

TABLE 5. LAMBING RECORD

	Lot 1 0.5% NaCl	Lot 2 4.8% NaCl	Lot 3 9.1% NaCl	Lot 4 13.1% NaCl
At birth:				
No. of ewes bred	10	10	10	10
No. of ewes lambed	9	9	10	7
No. of lambs born	11	13	12	10
Lambing, %	110	130	120	100
During lactation:				
No. of ewes that raised lambs	8	9	9	5
No. of lambs raised	9	11	11	7
Av. gain of lambs for first 28 days, lb.	18	16	16	14
Lbs. of lamb produced per ewe, first 28 days [1]	20	19	19	20
Av. gains of lambs on pasture	17	13	17	13

[1] Includes only ewes rearing lambs.

Summary

Female sheep were fed rations with a sodium chloride content of 0.5, 4.8, 9.1, and 13.1 percent for 253 days during growing and fattening, breeding, gestation, and early lactation. These levels of sodium chloride in the ration did not cause any significant difference between lots during the growing and fattening period. There was no difference in weight gain between groups during breeding and gestation. Weight loss during lactation was greater to a highly significant degree for the ewes on 13.1 percent NaCl. There was some decrease in number of lambs raised by the ewes on the highest salt intake. The addition of large amounts of sodium chloride to the ewes' rations did not affect the gains of the lambs. High sodium chloride intakes did not affect blood hematocrits or serum albumin and sodium, but an increase in blood serum chloride was observed. The milk protein, sodium, and potassium did not change; however, milk chlorides increased for all the lots on high sodium chloride intake.

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EFFECT OF AUREOMYCIN SUPPLEMENTS ON SUCKLING LAMBS [1]

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THE value of aureomycin supplements for increasing growth and thrift of ruminants has been demonstrated by Rusoff (1950) and Loosli and Wallace (1950). Bartley *et al.* (1950) concluded that the increased growth of calves was due to the prevention of scours.

Colby *et al.* (1950a) reported that the feeding of 100 mg. of aureomycin caused loss of appetite, diarrhea and loss of weight of feeder lambs. In additional work, Colby *et al.* (1950b) were not able to detect any beneficial results when 0.5–1 percent A.P.F. supplement containing 0.6 mcg. vitamin B_{12} and 4.0 mg. aureomycin per gm. was included in a ration fed to suckling lambs. Jordan (1952) concluded that aureomycin did not consistently increase rate of gain or feed consumption of feeder lambs, but that it appeared to decrease death loss due to over-eating disease in one trial.

Prier *et al.* (1952) in a study comparing suckling lambs treated with a subcutaneous implantation of 6,000 units of bacitracin with untreated suckling lambs reported a consistant difference in weight in favor of the treated lambs. Conversely, Terrill *et al.* (1953) obtained no increase in weaning weights or survival of pigs to weaning by subcutaneous implantation of bacitracin, penicillin or aureomycin pellets shortly after birth.

Experimental Procedure

In the first experiment suckling lambs ranging from two to six weeks of age were used as test animals. Aureomycin hydrochloride was administered in trial I by putting it into solution and drenching each lamb daily with 5 mg. The lambs had access to a mixture of corn, oats and bran in a creep. In trials II, III and IV, the aureomycin source was Lederle's Aurofac A which contained 1.8 gm. of aureomycin and

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1.8 mg. of vitamin B^{12} per pound. Four pounds of Aurofac supplement was mixed with 100 pounds of soybean meal and the mixture pelleted to facilitate feeding. In the second and third trials, the soybean-aureomycin mixture was mixed with shelled yellow corn in a ratio of approximately 1:4, and this mixture was offered to the lambs in a creep. This high proportion of protein supplement was necessary in order that each lamb receive approximately 5 mg. of aureomycin daily during the course of the experiment. In the fourth trial, 0.15 pound of the soybean meal-aureomycin pellets, which provided 10.8 mg. of aureomycin was fed per lamb daily.

Purebred Rambouillet lambs were used in the first trial, purebred Columbias in the second and forth, and purebred Corriedales in the third trial.

The procedure followed in the second experiment was as follows: Eighty mg. of aureomycin hydrochloride was implanted subcutaneously near the forerib of half the lambs in trials I and II. Coriedale lambs were used and the implantations were made when the lambs were 6–9 days of age. In the third trial No-tail lambs received 80 mg. of aureomycin implanted in alternate lambs at one day of age in the same manner as in trials I and II. Creep feeding was not practiced in these three trials.

Results and Discussion

The results of the four trials in which suckling lambs were either drenched daily with 5 mg. of aureomycin hydrochloride or fed supplements containing aureomycin are given in table 1.

Over a period of 42 days, the lambs drenched with aureomycin gained 0.64 pound per head daily as compared to 0.55 pound for the control lambs. Since these lambs were handled in one group, no record of feed intake is available. During the course of the experiment, it was observed that normal rumination was taking place and that there were no apparent abnormal digestive disturbances. The period covering the first four weeks of the experiment was rainy and cold. During this period, the greater rate of gain, over-all thrift and bloom of the treated lambs were most apparent.

In the second trial, in which the lambs were fed aureomycin in the form of Aurofac-supplemented pellets, the average daily gain of the supplemented lambs was 0.73 pound as compared to 0.65 pound for the control lambs. Because the lambs were creep fed, the amount of feed consumed and consequently the amount of aureomycin consumed

increased as the experiment progressed. Toward the end of the feeding period, lot 1 was consuming about 0.60 pound of the mixture of corn and protein pellets and lot 2 an equal amount of corn and aureomycin-supplemented pellets. Thus, the aureomycin-fed lambs were receiving 8–9 mg. of aureomycin per head, daily, during the late stages of the feeding period. The feed required per 100 pounds of gain was less

TABLE 1. EFFECT OF AUREOMYCIN SUPPLEMENTED ON SUCKLING LAMBS

Items	Trial I		Trial II		Trial III		Trial IV	
	Lot 1	Lot 2	Lot 1	Lot 2	Lot 1	Lot 2	Lot 1	Lot 2
Number of lambs	10	10	22	23	19	18	24	20
Days fed	42	42	33	33	50	50	50	50
Aureomycin [1] per lamb daily, mg.	None	5.0	None	4.32	None	4.32	None	10.8
Av. initial wt., lb.	25.7	25.4	21.3	18.8	22.8	23.7	23.7	24.5
Av. final wt., lb.	49.0	52.1	42.7	43.0	53.3	52.2	51.8	57.5
Gain per lamb, lb.	23.3	26.7	21.4	24.2	30.5	28.5	28.1	33.0
Av. daily gain, lb.	.55	.64	.65	.73	.61	.57	.56	.66
Death loss	0	0	0	0	0	0	0	0
Av. daily feed consumed, lb.								
Grain			.25	.24	.33	.25	.62	.70
Protein supplement			.06	.06	.08	.06	.15	.15
Total			.31	.30	.41	.31	.77	.85
Feed per 100 lb. gain Grain and protein supplement, lb.			48.0	41.0	67.0	62.0	137.0	129.0

[1] Administered orally as a drench in trial I.

for the aureomycin-fed lambs and, while it is recognized that the majority of the gain resulted from the dam's milk, the difference indicates that the aureomycin did not adversely affect the digestive system.

In the third trial, the plan of feeding the aureomycin was similar to that in the second trial. The average daily gain of the control lambs was 0.61 pound as compared to 0.57 pound for the aureomycin-supplemented lambs. In this trial, the feed consumption of the treated lot was lower than that of the controls and the lambs had a tendency to leave the soybean-aureomycin pellets. This lower feed intake may account for the lower gains.

Soybean-aureomycin pellets from the same batch as fed in the third trial were fed in the fourth trial. During the first 6 days, the

lambs left some of the soybean meal-aureomycin pellets, and their total feed consumption was less than that of the controls; but shortly thereafter, their appetites improved and their feed consumption during the entire trial exceeded that of the controls. The lambs receiving 10.8 mg. of aureomycin per head, daily, made an average daily gain of 0.66 pound as compared to 0.56 pound by the control lambs. Feed per 100 pounds of gain was slightly less in the treated group. While the treated lambs gained 12 to 17 percent faster than the controls in trials I, II and IV, these differences were not statistically significant.

The results of implanting 80 mg. of aureomycin into either day-old or week-old lambs are presented in table 2.

TABLE 2. EFFECT OF SUBCUTANEOUS IMPLANTATION OF AUREOMYCIN ON SUCKLING LAMBS

	Trial I		Trial II		Trial III	
Items	Lot 1	Lot 2	Lot 1	Lot 2	Lot 1	Lot 2
Number of lambs	11	10	15	15	35	36
Days fed [1]	66	66	60	60	34–54	34–54
Aureomycin implanted, mg.	None	80	None	80	None	80
Av. initial wt., lb.	12.5	13.0	12.5	13.9	9.6	9.5
Av. final wt., lb.	45.9	50.6	43.8	43.5	33.9	32.9
Gain per lamb, lb.	33.4	37.6	31.3	29.6	24.3	23.4
Av. daily gain, lb.	.51	.57	.52	.49	.53	.51
Death loss [2]	0	0	0	0	2	1

[1] Since the lambs were treated at different times but taken off the experiment at the same time, the length of time on trial varied.
[2] Death loss due to natural causes.

Skin irritation at the site of the implant was not evident in any of the treated lambs. In the first trial, the control lambs gained 0.51 pound per lamb, daily, as compared to 0.57 pound for the treated lambs. However, in the second and third trials the treated lambs gained slightly less than the controls. None of these differences was significant.

Summary

The results of four trials in which aureomycin was fed to suckling lambs, and of three trials in which 80 mg. of aureomycin hydrochloride was subcutaneously implanted, are presented.

1. Suckling lambs consuming an average of 4.3, 5.0 and 10.8 mg. of aureomycin per day for 33–50 days showed no digestive disturbances. The average daily gain of the aureomycin-fed lambs exceeded that of

the controls by 0.08–0.10 pound in three of the four trials. Statistical analysis failed to show significance, however.

2. Feed per 100 pounds of gain was slightly reduced in the aureomycin-supplemented lots.

3. Aureomycin did not increase feed consumption.

4. Eighty mg. of aureomycin subcutaneously implanted near the forerib of lambs 1–7 days old caused no apparent physiological effects and had no significant effect on rate of gain.

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THE EFFECT OF YEAR, BREED, AGE AND NUMBER OF EWES BRED ON FERTILITY IN RANGE RAMS

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THERE appears to be little experimental evidence regarding the age at which range rams should be placed in service or the number of ewes that should be allotted to rams of different ages. In an earlier paper Wiggins *et al.* (1953) reported on correlations of age of ram and the number of ewes bred with percentages of ewes lambing. The results of a more detailed study of the effect of these and other factors on ram fertility are reported in this paper.

Materials and Methods

Data on the breeding performance of 1109 rams bred to 31,473 ewes over the 15-year period 1936 to 1950, inclusive, were available for study. Since some of the rams and most of the ewes were in the flock for more than one year these figures are not the numbers of individual animals used in the study but rather the numbers of independent observations for the various items studied.

The breeds and ages of the rams involved and details of their management before and during the breeding season were given by Wiggins *et al.* (1953).

The semen of all rams used was examined before the beginning of the breeding season as described by Terrill (1937) and Wiggins *et al.* (1953). In most cases only those rams whose semen appeared to indicate that they were potentially highly fertile were used in breeding, but the nature of the breeding program necessitated the use of a few rams with semen ranging from questionable to definitely poor quality.

Results and Discussion

Fertility of Rams in Different Years

The overall 15-year average percentage of ewes lambing was 90.7 (table 1). The yearly percentages ranged from a low of 87.9 in 1946 to a high of 93.7 in 1950. There did not appear to be any definite trend

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TABLE 1. EFFECT OF YEAR AND BREED ON FERTILITY IN RANGE RAMS

	1936		1937		1938		1939		1940		1941		1942		1943	
Breed	No.	% [1]	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Ramb.	3	88.0	31	92.6	43	89.7	64	88.7	64	90.6	56	88.9	55	88.9	46	88.2
Targ.	1	100.0	2	98.0	0	....	5	95.0	8	93.9	10	92.9	8	92.6	12	92.9
Col.	3	93.3	4	88.5	2	88.0	12	93.2	16	90.8	15	92.1	14	85.8	20	93.3
Corr.	2	94.5	2	97.0	2	100.0	4	97.0	4	80.0	5	94.4	4	91.8	4	89.2
Misc.[2]	0	....	3	78.7	1	67.0	0	....	0	....	0	....	0	....	0	....
All	9	92.6	42	91.7	48	89.6	85	90.1	92	90.5	86	90.2	81	88.9	82	90.2

	1944		1945		1946		1947		1948		1949		1950		Total	
Breed	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Ramb.	52	93.0	33	93.4	37	89.8	39	93.4	37	90.3	48	89.4	58	93.8	666	90.6
Targ.	9	91.9	11	92.0	18	94.3	22	91.3	25	83.6	25	25.9	32	95.2	188	92.5
Col.	23	91.1	16	86.6	17	83.2	19	92.7	15	91.3	19	87.5	18	90.7	213	89.9
Corr.	4	87.8	0	....	0	....	0	....	0	....	0	....	0	....	31	91.6
Misc.[2]	0	....	1	97.0	4	60.8	1	97.0	1	93.0	0	....	0	....	11	75.7
All	88	92.1	61	91.7	76	87.9	81	92.7	78	88.4	92	90.8	108	93.7	1109	90.7

[1] Average percentage of ewes lambing per ram.
[2] This group consisted of 7 Merinos, 3 Lincolns and 1 Border Leicester.

in fertility over the period of study. Unweighted means of percentages of ewes lambing by 5-year periods were 90.87, 90.62 and 90.68 for the first, second and third periods, respectively. Thus it appears that if any factors were operating to cause a long-time upward trend in fertility (e.g. improvements in management and/or nutrition) they were opposed by other factors that tended to cause decreases in fertility of about the same magnitude.

Many range sheepmen feel lamb production in one year is influenced by the previous year's production with a year of low lamb production being followed by a year of high lamb production and vice-versa. There is little support for such an idea in these data.

Effect of Breed on Fertility

Rams of the Rambouillet and Columbia breeds were used in each of the 15 years. Targhee rams were used every year except 1938 and Corriedale rams were used in each of the 9 years 1936–1944 inclusive. A total of 11 rams of 3 other breeds was used in 6 different years. Because of the small number of rams in any one breed these 11 rams have been considered as one group.

Targhee rams had the highest average percentage of ewes lambing followed in order by Corriedales, Rambouillets, Columbias and rams of the miscellaneous group (table 1). It can be seen from table 1 that when Rambouillets, Targhees and Columbias were compared in each of the 14 years that all 3 breeds were represented, Targhee rams were highest in fertility in 9 years, intermediate in 3 years and lowest in only 2 years. In the same manner Rambouillets were highest in fertility in 3 years, intermediate in 6 years and lowest in 5 years. Corresponding figures for Columbias were 2, 5 and 7. When Corriedales were compared to Rambouillets, Targhees and Columbias in each of 8 years that all 4 breeds were represented they were found to rank first in fertility in 2 years, second in 3 years, third in one year and last in 2 years. However, it should be noted that the number of Corriedale rams used in any one year was quite small and therefore their "rank" in comparison with other breeds is probably unimportant. The 11 rams of the miscellaneous breeds were quite low in fertility but it is emphasized that the semen of several of these rams was known to be of poor quality at the time they were used. Had they not been purchased for a particular purpose in the breeding program or if "reserve rams" had been available, several of the rams would not have been used because they were considered to be poor breeding risks. Furthermore the number of

rams in any of the breeds represented is entirely too small to be any indication of the average fertility of the breeds they represent.

It is emphasized that these data on the relative fertility of different breeds of rams have several limitations. Probably the most important limitation is that, with the exception of the 11 rams of the "miscellaneous" breeds, most of the rams were mated to ewes of their own breed. Therefore the breed comparisons of fertility are not necessarily comparisons of fertility of different breeds of rams but rather of the overall breed fertility as affected by fertility of both rams and ewes under conditions prevailing at this Station. Another limitation is that the semen of the prospective breeding rams was examined before breeding and practically all rams with poor quality semen were rejected. Thus the rams used were selected samples of their breeds. It could also be argued that with the exception of the Targhee and Columbias (those 2 breeds originated at this Station) the rams used were not necessarily representative samples of their breeds.

Effect of Age of Ram on Fertility

Rams 4 years old and older had the highest percentage of ewes lambing and were followed in order by 2-year olds, yearlings, lambs and 3-year olds (table 2.) A year-by-year comparison of fertility of rams of different ages was made and with the exception that 2-year old rams were never lower than third in fertility, there was no apparent consistency in the "rank" of rams of different age groups over the 15-year period.

Wiggins *et al.* (1953) reported that the within-year, within-breed-and-type-of-mating correlation between age of ram and percentage of ewes lambing was not significantly different from zero in these same data. In an earlier study of fertility in this same flock Terrill and Stoehr (1939) reported that no definite change in fertility, due to age of ram, was found. Thus it appears that there are no really important differences in fertility of rams of different ages under the system of management followed at this Station. However, it should be remembered that these animals were selected for use partly because they had semen of good quality. The fertility of these selected rams of different ages may not be indicative of the relative fertility of unselected rams of the same ages. Furthermore rams 2 years old or older also had the advantage of previous culling for fertility in actual breeding because all rams whose breeding records were poor at yearling or older ages were sold for slaughter before the next breeding season regardless of the

TABLE 2. EFFECT OF AGE AND NUMBER OF EWES BRED ON FERTILITY IN RANGE RAMS

	Number of Ewes Bred per Ram															
	5–10		10–19		20–29		30–39		40–49		50–59		60–65		Total	
Age	No. Rams	Ave. % Preg.	No. Rams	Ave. % Preg.	No. Rams	Ave. % Preg.	No. Rams	Ave. % Preg.	No. Rams	Ave. % Preg.	No. Rams	Ave. % Preg.	No. Rams	Ave. % Preg.	No. Rams	Ave. % Preg.
Lambs	2	94.0	22	92.8	85	87.5	24	90.6	1	98.0	1	90.0	0	....	135	89.1
1 yr.	14	87.3	54	94.2	262	90.6	122	90.1	43	92.9	19	89.8	2	92.5	516	90.9
2 yr.	2	100.0	14	88.5	97	91.1	62	92.7	21	91.2	7	89.9	1	87.0	209	91.4
3 yr.	1	100.0	11	88.3	52	87.4	29	90.4	22	90.4	6	93.3	4	86.0	125	89.0
4 & over	0	....	8	91.6	59	92.4	33	92.3	13	93.1	9	85.1	2	88.0	124	91.8
All	19	90.0	114	92.3	555	90.1	270	91.0	100	92.1	42	89.3	9	88.0	1109	90.7

apparent quality of their semen. Thus each succeeding age group had the benefit of an increased number of cullings for poor fertility. This might tend to improve the breeding performance of the older rams above the level that would have prevailed without prior culling. Another factor that might tend to favor the older rams is that in recent years considerable emphasis has been given in the breeding program to turning the ram generations over as rapidly as possible. Therefore, an older ram whose semen was of questionable quality in any respect would be less likely to be used than a younger ram of the same line whose semen was of similar quality. In view of the insignificant differences between rams of different ages in these data and the likelihood that most of bias, if any, would be in favor of older rams, there appears to be little support for the belief held by many sheepmen that older rams are of higher fertility or may safely be bred to larger numbers of ewes than younger rams (Johnston, 1953).

Effect of Number of Ewes Bred on Fertility

The number of ewes bred to a single ram during a breeding season of approximately 30 days ranged from 5 to 65. For study, the pens of different sizes were grouped in multiples of 10 ewes, i.e. less than 10, 10–19, 20–29 ewes, etc.

The average percentage of ewes lambing in the 2 groups containing 50 or more ewes per pen was slightly lower than any of the pen groups of smaller numbers of ewes. There was no trend in fertility with increasing numbers of ewes up to 50. Thus it appears that individual rams whose semen is known to be of good quality at the beginning of the breeding season can be bred to at least 50 ewes in a 30-day breeding season without a reduction in the percentage of ewes lambing. The reduction in fertility appears to be slight when as many as 65 ewes are bred to a single ram.

It will be noted that in 2 cases ram lambs were of satisfactory fertility when bred to more than 40 ewes and the average fertility was also satisfactory for 24 other lambs that were bred in pens of 30 to 39 ewes. It is emphasized that these lambs were the older, larger lambs from their respective groups. Also they had enough libido to serve ewes under rather artificial conditions and had been found to have semen of reasonably high quality before they were used in breeding. This may explain the difference between the results reported here and the earlier results of using untested ram lambs in this same flock. Terrill and Stoehr (1939) reported that while only 2 ram lambs were

used, both were of low fertility. Therefore these results should not be interpreted as being representative of the breeding performance of ram lambs in general. The results do indicate, however, that some ram lambs may be used in breeding with entirely satisfactory results particularly if facilities are available to determine before breeding that they have the ability and desire to mate and have semen of reasonably good quality. Since Dickerson and Hazel (1944) have shown that the annual rate of genetic improvement in a flock depends partly on the length of the generation interval it would appear that the judicious use of ram lambs would be a means of hastening the rate of improvement in a breeding program.

Discussion

These data are not entirely satisfactory for studying the effect of various factors on fertility in rams. They were obtained on rams that were known to have semen of acceptable quality before they were used in breeding and in the case of older rams, had had a satisfactory breeding record in the past. This selection may have biased the results since it is obvious that even if 2 or more groups (breeds, ages, etc.) were actually quite different in average semen quality and in average potential fertility it might be possible to select samples of rams from the groups that would have semen of similar quality and that would be of equal fertility thus giving a false picture of the average fertility of the groups from which they came. Unfortunately, no good estimate can be made of the amount of selection practiced because in most years the semen was examined only in rams that had been selected for use in breeding on the basis of their other traits and the semen of the "reserve" rams was not examined except in those cases where the "first choice" rams had semen of doubtful quality.

Taken at their face value these data do not indicate important differences in fertility of rams of different ages. Furthermore it seems likely that, with the exception of ram lambs, most of the bias would probably be in favor of the older rams. Therefore, it appears that fertility in a flock would not be decreased and might even be increased by the extensive use of young rams (yearlings and 2-year olds). This is important since the rate of improvement from selection is usually most rapid when the generation interval of rams is kept as short as possible. These data also indicate that selected ram lambs can be used without lowering the fertility of the flock.

These data do not indicate any decrease in fertility when rams are bred to increasing numbers of ewes up to 50. There was some indication that the average fertility was lower in pens of 50 to 65 ewes, although too few rams were used in pens of this size to definitely establish the point. Terrill and Stoehr (1939) did report a significant negative correlation between percentages of ewes lambing and the number of ewes bred per ram when the number of ewes per ram ranged from 5 to 93 and the average number was 48. More data are needed on the breeding performance of rams bred to large numbers of ewes to determine the largest number of ewes that can be bred to a ram without a decrease in fertility. While it is true that most of the rams used in this study were bred in pens or small pastures and it was known that they had semen of acceptable quality before breeding began, the results of this study and the study by Terrill and Stoehr (1939) suggest that the usual allotment of 3 rams per 100 ewes in range breeding (Ensminger, 1952) might be somewhat high. The ratio of 3 rams to 100 ewes could almost certainly be reduced if the ranchers would examine the semen of rams before breeding. Actually a rough appraisal of ram semen, which is often sufficient for practical purposes can be made with very simple and inexpensive equipment (Terrill, 1952). The use of fewer rams would reduce the cost of breeding the ewes and could result in higher selection differentials for traits of economic importance particularly if the rancher was using rams of his own breeding. This would tend to increase the rate of genetic improvement in his flock.

Summary

The effects of year, breed, age of ram and number of ewes bred per ram were studied in 1109 rams bred to 31,473 ewes over the 15-year period 1936–1950 inclusive.

The average percentages of ewes lambing in different years ranged from a low of 87.9 percent in 1946 to a high of 93.7 percent in 1950. No definite trend in fertility was noted over the period studied. The average percentage of ewes lambing over the period of study was 90.7.

Targhee rams had the highest average fertility followed in order by Corriedales, Rambouillets, Columbias and 11 rams of 3 other breeds which were considered as one group.

There did not appear to be significant differences in the fertility of rams of different ages and there was no trend in fertility with increasing age. In actual percentages of ewes lambing 4-year old rams were

highest and were followed in order by 2-year olds, yearlings, 3-year olds and ram lambs.

There was no trend in fertility with increasing numbers of ewes up to 50. The average fertility in pens of more than 50 ewes was slightly lower than the fertility in pens of less than 50 ewes but only a relatively small number of rams were bred to more than 50 ewes.

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FERTILITY RATE AND EMBYRONIC DEATH LOSS IN EWES EARLY IN THE BREEDING SEASON [1]

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IT is important for ewes to conceive at the first or second heat period of the breeding season in sections of the country where the lambs are produced to finish on pasture and go to market off the ewes. An early and uniform lamb crop depends upon breeding early in the season and upon fewer repeat breedings in the ewe flock.

This study was designed to determine the nature of reproductive failure in ewes bred early in their estrual season. Characteristics studied were the ovulation rate, the fertilization rate, condition of the ova or embryos at three days post-breeding, the embryonic death loss and any structural abnormalities of the reproductive tract which might prevent union of the sperm and ovum.

Materials and Methods

Crossbred, dark-faced, northwestern ewes which had been brought to Kentucky as lambs and wintered over in the bluegrass region were used in this study. Sixty yearling ewes were bred each season for the 1948, 1949, and 1950 breeding seasons, and a total of one hundred and eighty ewes were thus included in the study.

Breeding was started as soon as sufficient numbers of ewes came into heat that the planned breeding program could be followed. This was usually during the last week in August and breeding was continued through September. The ewes were checked twice daily at 12-hour intervals with aproned teaser rams and a ewe was considered to be in heat when she would stand and allow the ram to mount. The ewes were paired as they came in heat and each member of a pair was inseminated with 0.2 ml. of a split portion of fresh undiluted semen. The semen used was in all cases from purebred Southdown rams and was collected by use of an artificial vagina. Quality of the semen produced during this period of the year was not very high as judged by motility rating; however, no ejaculate of semen showing less than 20 percent motile cells as judged by microscopic examination was used for

[1] The investigation reported in this paper is in connection with a project of the Kentucky Agricultural Experiment Station and is published by permission of the Director.

insemination. Three rams were used each year with each ram furnishing semen to breed an equal number of the ewes. Preliminary checking for heat showed that the ewes would stand for the ram from 3 to 5 checks during one heat period; therefore, in order to achieve maximum fertility, all ewes were inseminated at the third heat check, since it has been reported that ovulation in the ewe occurs near the end of estrus. (Green and Winters, 1935; McKenzie and Terrill, 1937).

One ewe from each pair was chosen randomly to be slaughtered three days after breeding. These 90 ewes made up the slaughter group in which fertilization or cleavage of the ova was detected. The other ewe of each pair was checked daily for return to heat for a period of two months. Ewes returning to heat were considered not pregnant and those not returning to heat were allowed to go to lambing time and the number of lambs born was recorded. These ewes made up the control group.

As soon as the reproductive tract was removed from the slaughtered ewes, it was taken to the laboratory for examination. After an examination was made of the ovaries, the oviducts were separated from the mesosalpinx, detached from the uterus at the cornual junction, and flushed with Krebs solution to recover the ova. The ova were located in the flushings by use of a dissecting binocular microscope, and routinely were placed on a hanging drop slide and examined under the high power of a microscope to determine their condition. An examination of the cervical canal was made to determine whether it was open and both oviducts were checked by flushing for any possible obstruction which might prevent fertility.

The slaughter group of ewes thus furnished information on the ovulation rate, fertilization rate, condition of the ova or embryos and the presence of any structural abnormality of the reproductive tract. The control group furnished information on the percentage of ewes lambing and on the lambing rates. Embryonic death loss is considered to be the difference between the fertilization rate and the lambing rate.

Results and Discussion

For the three seasons the earliest date of breeding was August 24 and the latest date was October 6 with the average date of breeding being September 14. Of the 90 pairs of ewes, 79 pairs were inseminated with split portions of a semen sample. Due to the randomness with which ewes in a flock come into heat, it was not possible to pair all ewes on the above basis. Accordingly 11 pairs were inseminated with

semen of different ejaculates from the same ram. The methods of pairing showed no difference in fertility and embryonic death; therefore, no distinction in the method of pairing except where noted is made in presenting these data.

Ovulation Rate

All of the 90 ewes in the slaughter group had at least one recently formed corpus luteum, and the ovarian tunic was ruptured in all cases; however, ova were not recovered from two of the ewes. A total of 132 corpora was present with an average of 1.47 ovulations per ewe. In only one case was a triple ovulation observed and very little variation in ovulation rate between the three years was found (table 1). No

TABLE 1. OVULATION RATE, FERTILIZATION RATE, AND ABNORMAL OVA IN THE SLAUGHTERED GROUP OF EWES

Year	No. of Ewes	No. of Corpora Lutea [1]	Ova Recovered			Abnormal Ova		
			Fert.	Unfert.	Total	Fert.	Unfert.	Total
1948	30	45	17	27	44	5	6	11
1949	30	46	24	18	42	2	5	7
1950	30	41	29	12	41	3	5	8
Total	90	132	70	57	127	10	16 [2]	26
Percent	...	...	55.1	44.9	96.2	14.3	28.1	20.5

[1] All ewes in the slaughtered group had at least one recently formed corpus luteum. Ovulation rate, 1.47 per ewe.

[2] The zona pellucida was cracked or broken in seven of these ova, the vitelline membrane appeared to be ruptured in six ova and three ova were partially collapsed.

structural abnormality which might prevent passage of the ova into the uterus or prevent fertilization was found. One ewe had two services and the anterior part of the vagina was bifurcated, but this condition would not necessarily prevent fertilization except possibly when the semen was deposited at the cervical os opposite the side in which ovulation had occurred in only one ovary.

The number of ova found was five less than the total number of corpora lutea present (table 1). The ova recovered in the flushings represent 96.2 percent of the corpora. It is possible that faulty technique may be responsible for failure to locate the five missing ova; however, it may be that the ova were entrapped in the developing corpora or that they were not picked up by the infundibulum or funnel after they had been released from the follicle. From this study it does not appear that failure to ovulate represents a major factor in the re-

productive loss in ewes bred at the beginning of their normal estrual season.

Fertilization Rate

Of the 127 ova recovered from the slaughter group of ewes, only 70 or 55.1 percent were fertilized as was determined by the presence of two or more blastomeres of equal size when examined under high power of the microscope. Most of the cleaved ova were found to be in the 4 to 8-cell stage of development. A significant difference between years in the percentage of fertilized ova was found when the data were tested by Chi square. Multiple ovulations occur in the ewe and frequently in these cases one ovum is found to be fertilized while the other is not. In this study all ewes with one fertilized ovum, regardless of the number ovulated, are included in the group of slaughtered ewes having fertilized ova. Of the 90 ewes in the slaughter group, 55 or 61.1 percent had one or more fertilized ova.

An important factor in fertility is the quality of semen, and the motility of semen is commonly used as a measure of its fertilizing capacity. Some information on the effect of quality of semen on fertility in these ewes is available since the motility rating of the semen used for insemination was recorded and the effect on the fertilization rate and on embryonic death loss can be studied. Only the 77 pairs of ewes inseminated with split portions of an ejaculate of semen and from which ova were recovered from the slaughtered ewe of a pair are included in this analysis. The semen was divided into two groups on the basis of motility rating; (1) from 20 to 50 percent motile cells, and (2) 60 percent or more motile cells. Estimates of motility were made at intervals of 10 percent. The fertility and lambing data from the ewes inseminated with semen of different motility rating are shown in table 2. The fertility of the ewes inseminated with the semen of higher motility was significantly higher than in those inseminated with semen of lower motility, probability less than .01. There was very little difference between the two groups in the percentage of ewes in which embryonic death occurred (30.0% vs. 30.5%). The percentage of ewes which lambed as a result of one breeding was twice as high in the ewes inseminated with semen of higher motility.

Numerous workers (Grant, 1933; Cole and Miller, 1935; and, Roux, 1936) have reported that a common characteristic of the ewe is to have a quiet heat accompanied by ovulation prior to the onset of the first heat of the estrual season. Physiologically this might be beneficial

in improving the fertility rate through better uterine environment. To shed some light on this assumption the presence or absence of corpora albicantia was determined by gross examination of the ovaries at time of slaughter. The percentage of ewes from which fertilized ova were recovered was then determined for the two groups of ewes resulting from the above classification. The ovaries of only 12 ewes or 13.3 percent of the slaughtered group contained no corpus albicans; thus, these

TABLE 2. RELATIONSHIP BETWEEN MOTILITY RATING OF SEMEN USED FOR INSEMINATION AND FERTILITY AND EMBRYONIC DEATH LOSS

	Group				
	Slaughter		Control		Estimated Percent of Ewes in Which Death of Embyro Occurred
Motility Rating of Semen	No. of Ewes Bred	Percent of Ewes with Fert. Ova	No. of Ewes Bred	Percent of Ewes Lambed	
(percent)					
20 to 50	27	37.0	27	25.9	30.0
60 and above	50	72.0[1]	50	52.0	30.5

[1] Probability of less than 0.01.

ewes probably had not ovulated prior to the heat period when bred. The ovaries of 78 of the ewes contained at least one corpus albicans, which is evidence that these ewes had probably ovulated prior to the heat period at which they were bred. It should be pointed out that the above figures should not be interpreted as an estimate of the frequency of quiet ovulations in ewes prior to the first estrus, since breeding was not necessarily restricted to the first heat.

Of the 12 ewes having no corpora albicantia, 5 or 41.7 percent had fertilized ova, while from 76 ewes with corpora albicantia on their ovaries (no ova were recovered from 2 ewes) 50 or 65.8 percent had fertilized ova. Although the percentage of fertilized ova from ewes having corpora albicantia on their ovaries was 50 percent higher than from ewes having no corpora albicantia, this difference was not significant when tested by Chi square, probability of approximately 0.1.

Abnormal Ova and Embryos

Sixteen of the 57 unfertilized ova or 28.1 percent were classified as abnormal (table 1). Seven of these had either a cracked or a broken zona pellucida. In 6 of the abnormal uncleaved ova the vitelline membrane was ruptured or the cytoplasm was shrunken to a much reduced

size. Three unfertilized ova were partially collapsed and were considered to be abnormal. Photomicrographs of some abnormal ova as well as a normal two-cell ovum are shown in figure 1.

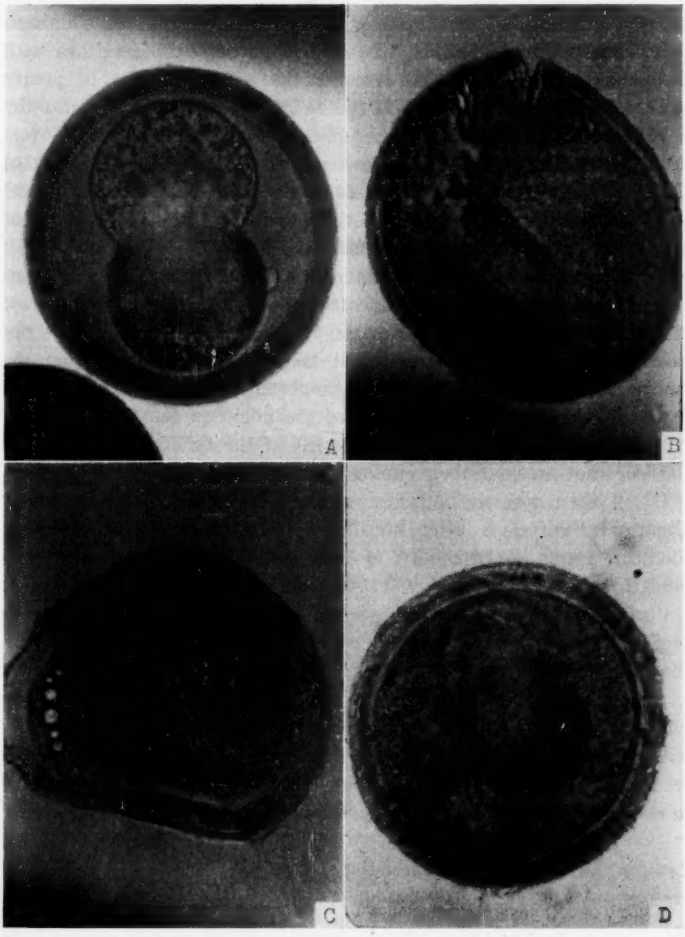

Figure 1. Photomicrographs of normal and abnormal ova.
A. Normal two-cell ovum. X 430.
B. Ovum with broken zona pellucida. X 430.
C. Shrunken ovum. X 430.
D. Fertilized ovum with degenerating cells. Loose granules of cytoplasm can be seen in the lower part of the picture. X 430.

It appears doubtful that the flushing technique could have caused the zona pellucida to become cracked or broken, since this condition was determined while the ova were still in the flushings from the fallopian tubes. Thus the possibility that a break in the zona pellucida may have been caused by pressure between a microscopic slide and cover slip was eliminated. The recovery of partially-collapsed ova with shrunken cytoplasm may be evidence that some ova are of poorer quality than others and had started to degenerate. There is also the possibility that these ova with shrunken cytoplasm may be hold-overs in the fallopian tubes from a previous heat period. The frequency of this is probably rare, but in one case two normal-appearing ova and one with shrunken cytoplasm were recovered from the fallopian tube of a ewe having only two recent ovulation points.

Some of the cleaved ova had fragmented cells and were not developing normally. Ova having fragmented cells represent 14.3 percent of all ova showing cleavage. The reason for these fragmented cells is not known, but it can be assumed that they are an indication that the embryo is dead. Blandau (1952) has reported that delayed fertilization in the rat results in fragmentation of the nuclei in the two-cell stage. All ewes in this study were still in heat at the time of breeding, but this does not preclude their having already ovulated.

Of all ova recovered, both cleaved and uncleaved, 20.1 percent were abnormal three days after breeding. No report was found in the literature giving the percentage of abnormal ova which occur in normal ovulating ewes. Tanabe *et al.* (1949) reported recovering empty zona pellucidas from hard-to-settle cows slaughtered three days after breeding, and Murphree *et al.* (1944) reported recovering cleaved ova with fragmented cells from ewes that had been treated with gonadotrophic hormone to induce ovulation. The percentage (20.1) of abnormal ova and embryos found in ewes in this study may be somewhat higher than that normally found in ewes during the peak of the breeding season, but it may be one important reason for poor fertility observed in ewes when bred at the beginning of their estrual season.

Lambing Rate and Embryonic Death Loss

Thirty-seven or 41.1 percent of the control ewes did not return to heat and lambed (table 3). Of the 53 ewes in the control group which did not lamb, all but two returned to heat in less than 20 days after they were bred. If the number of ewes with fertilized ova from the slaughter group is taken as an estimate for the number of ewes in the

control group having fertilized ova, then the estimated embryonic death rate is 32.7 percent (55 ewes in the slaughter group with fertilized ova vs. 37 ewes lambing). Thus, approximately one of every three ewes with fertilized ova at three days after breeding failed to lamb. It is evident that the greatest embryonic death loss took place quite early, i.e., before the first expected heat period after breeding,

TABLE 3. EMBRYONIC DEATH LOSS ESTIMATED FROM THE LAMBING DATA OF THE CONTROL EWES AND FERTILITY DATA OF THE SLAUGHTERED EWES

	Group						Embryonic Death Loss	
	Slaughter			Control				
Year	No. of Ewes Bred	No. of Ewes with Fert. Ova	No. Fert. Ova	No. of Ewes Bred	No. of Ewes Lambed	No. Lambs Born	Ewes with Fert. Ova Minus Ewes Lambed	Fert. Ova Minus No. Lambs Born
1948	30	14	17	30	11	14	3	3
1949	30	18	24	30	8	13	10	11
1950	30	23	29	30	18	26	5	3
Total	90	55	70	90	37	53	18	17
Percent	..	61.1	55.1	..	41.1	41.7	32.7	24.3

since only two (control ewes) or less than 4 percent of the pregnant ewes (based on slaughter data) returned to heat at an interval of more than 20 days after the date of breeding.

In the slaughter group, 70 of the recovered ova were cleaved, while in the control ewes 53 lambs were born (table 3). From these data the estimated embryonic death loss of fertilized ova is calculated to be 24.3 percent, or, about one of every four cleaved ova failed to develop to lambing time. Hammond (1921) found in a group of 22 sows that only 67.4 percent of the ova shed were represented by normal fetuses; however, no infertile matings were included in this study. Corner (1923) found in sows that approximately 10 percent of the fertilized ova degenerate by the time they reach the blastocyst stage and that another 5 to 10 percent become abnormal during later periods of gestation. The percentage of fertilized ova which failed to develop to lambing time in the present study in ewes is somewhat higher than the embryonic death loss reported by Corner for swine. In the present study, death of the embryo was found to be an important factor in lowering the percentage of ewes lambing to the first breeding.

The difference between the percentage of ewes with fertilized ova (61.1) and the percentage of ewes lambing (41.1) is an estimate of the percentage of ewes in which embryonic mortality occurred. This difference, 20.0 percent, is an estimate of the percentage of all the ewes bred in the control group which had fertilized ova but did not lamb. A ewe having a twin pregnancy and delivering only one lamb would not be included in the above estimate of embryonic mortality, and in this study no direct information on this condition is available. However, there is evidence that this did not occur frequently since the lambing rate of 1.43 per ewe is very close to the ovulation rate of 1.47 per ewe. Furthermore, when the number (1.27) of cleaved ova per ewe from which fertilized ova were recovered (70 cleaved ova from 55 ewes) is compared with the lambing rate of 1.43 lambs per ewe, it appears that embryonic death occurred in a higher percentage of ewes having single embryos than in those having twin embryos. Any attempt to explain this would be based merely upon conjecture; however, it may be that better uterine environment follows a twin ovulation possibly as a result of a higher level of hormonal action.

Altogether, from the data of the slaughter and control groups the reproductive performance of these ewes bred early in their estrual season may be classified as follows: (1) ewes with no fertilized ova, 38.9 percent; (2) ewes in which the embryo died, 20.0 percent; and, (3) ewes lambed, 41.1 percent.

Summary

In this study one hundred and eighty crossbred yearling ewes were paired as they came in heat and each was inseminated with 0.2 ml. of a split portion of undiluted semen. One ewe from each pair was slaughtered three days after breeding to determine the ovulation rate, the fertilization rate, condition of the ova and the presence of any structural abnormality which would prevent fertilization. The remaining ewes made up the control group and were checked for return to heat and allowed to go to lambing time.

All ewes (90) in the slaughter group had ovulated; the ovulation rate was 1.47 per ewe and 96.2 percent of the ova were recovered. Cleavage was evident in 55.1 percent of the ova. Including both the cleaved and uncleaved ova, 20.5 percent of all ova were classified abnormal by the third day after breeding. Of the cleaved ova, 14.3 percent were abnormal and 28.1 percent of those not showing cleavage were abnormal.

No structural abnormalities of the reproductive tract which would be a barrier to fertilization were found. Insemination with semen of high quality as judged by motility significantly increased the fertilization and lambing percentages but did not affect the embryonic death rate.

Using the ovulation and fertilization rates from the slaughter group as estimates in the control group, lambs born represent 41.7 percent of the ova recovered, and the embryonic death rate was found to be 32.7 percent. The reproductive performance of the ewes as a group may be classified as follows: (1) ova not fertilized, 38.9 percent; (2) death of embryo, 20.0 percent; and (3) lambed, 41.1 percent.

Failure of the ova to become fertilized was the most important factor in accounting for the low lambing rate.

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DIURNAL VARIATION IN THE ESTIMATES OF DIGESTIBILITY OF PASTURE FORAGE USING PLANT CHROMOGENS AND FECAL-NITROGEN AS INDICATORS [1, 2]

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WILDT (1874) was the first to use an indicator for the indirect determination of digestibility by the ratio-technique. He used silica, which occurs naturally in hay and straw. Since then, various inert materials have been used for this purpose. The literature on their use has been thoroughly reviewed recently by Soni (1953) and Kane *et al.* (1953a). Therefore, no attempt will be made to do so in this paper.

When determining the coefficients of digestibility of nutrients by the indicator methods, it is assumed that the reference substance passes through the alimentary tract at a uniform rate. If its rate of excretion is inconsistent, as was found by Kane *et al.* (1952) with chromic oxide and lignin, special sampling plans, if possible, are followed to adjust for the diurnal variation. If, on the other hand, the ratio of the indicator and the nutrients is the same during a period of 24 hours, only a small amount of feces collected at any time of the day or night is sufficient to give an estimate of digestibility.

In pasture research with grazing cows, it is very difficult, if not impossible, to make total collection of feces from a number of animals. Lignin, plant chromogens extracted with 85 percent acetone, and fecal nitrogen are some of the indicators used for determining the digestibility of pasture forages. Recently Kane *et al.* (1952) have shown a variation in the concentration of lignin in the individual passages of feces over a 24-hour period. This variation makes it necessary to collect large quantities of fecal samples at different intervals during the day and night so as to avoid high or low levels of lignin in the feces. As can be seen, this involves a great amount of labor and expense and thus limits the use of lignin as an indicator for pasture forage digesti-

[1] Scientific Paper No. 1276, Washington Agricultural Experiment Stations, Pullman. Project 1140.

[2] The assistance of Dr. Wendell E. Ham of the Department of Animal Husbandry is gratefully acknowledged.

[3] Point Four Trainee from Tezpur, Assam, India.

bility studies. Except for a preliminary report by Reid *et al.* (1952) for chromogens, the diurnal variation in the excretion of chromogens or fecal nitrogen has not been studied.

This paper reports a study made in order to determine the diurnal variation, if any, in the estimates of digestibility of pasture forages with grazing sheep and dairy cattle, using chromogen (Reid *et al.*, 1952) and fecal nitrogen (Lancaster, 1949) as indicators.

Experimental Methods

Six Holstein heifers and three wether sheep were used in this study. The different plots on which this trial was conducted were part of an old irrigated pasture at the Western Washington Experiment Station, Puyallup, Washington. Quackgrass (*Agropyron repens*) and Kentucky bluegrass (*Poa pratensis*) constituted the principal grass species of this pasture, but various other grasses and weeds were quite abundant. The experimental periods consisted of four and three days in the case of sheep and heifers, respectively. The heifers had been on the pasture for about two months before the start of experiment, so no special preliminary period was designated for them. The wethers were, however, allowed to graze in the pasture for a preliminary period of four days. These sheep were fitted with specially designed feces collection bags. Samples of the feces voided were collected out of the bags three times a day: eight o'clock in the morning, one o'clock in the afternoon, and five o'clock in the evening. Fecal samples from the heifers were also obtained at approximately the same times of the day, except for one day when samples were collected only twice. These samples were obtained by introducing the hand into the rectum of the animal and taking out sufficient feces so that aliquots could be taken for chemical analysis. The authors are aware of the limitations of using this technique on heifers and believe that the ideal method for such a study would have been to design and use some sort of apparatus for total fecal collection from grazing animals by following the procedure used with the sheep.

For the chromogen analysis, a five-gram aliquot was taken from each collection of feces, put in a small air-tight, amber-colored bottle, and covered with 80 percent acetone. These bottles were stored at a temperature ranging between 1° and 5° C. until such time as the chromogen content was determined by the method of Reid *et al.* (1952). For the remaining analyses, feces samples were stored in air-tight bottles at the same temperature. The ash and nitrogen content of the samples

collected from the sheep, and the dry matter of all samples were determined by the methods recommended by the Association of Official Agricultural Chemists (1945).

Results and Discussion

Figures 1 and 2 show graphically the content of chromogen and nitrogen in the sheep feces. The individual samples are expressed as

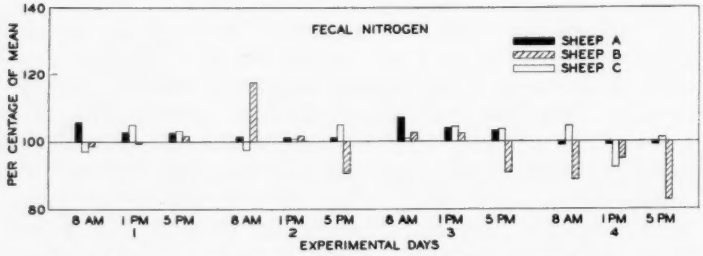

Figure 1. Excretion of fecal nitrogen expressed as percent of mean.

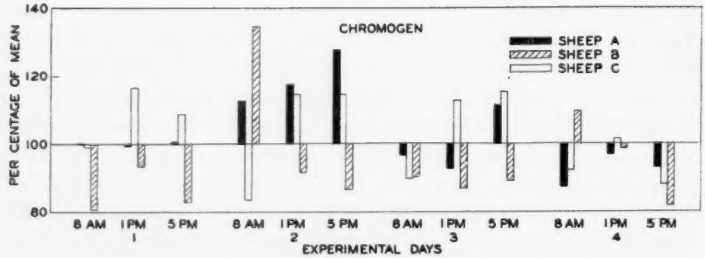

Figure 2. Excretion of fecal chromogen expressed as percent of mean.

percentage of the mean. It is clear from these figures that the variation in the chromogen content of the samples collected at different times during the day is very large and without special pattern. However, the variation in fecal nitrogen excretion is relatively small. The actual mean of all samples for fecal nitrogen is 2.71 percent (expressed as percent of organic matter). For chromogen, the mean is 767.03 units (expressed as units per gm. of feces on a dry matter basis).

Kane *et al.* (1952) studied the diurnal variation of chromium oxide and found that the chromium oxide content of the feces of three cows

rose to the highest point around 9:00 a.m. and thereafter decreased slowly until around 9:00 p.m. In the work reported herein, no such consistent peaks were noticed in the daily excretion rates of chromogen with sheep. Similarly this was true with the fecal samples obtained from heifers. The nitrogen content of sheep feces expressed on an organic matter basis was quite consistent. The variation between sheep, between day and within day, was not significant.

Tables 1 and 2 show the digestion coefficients of dry matter when values of chromogen obtained from individual samples were used in the

TABLE 1. DIGESTION COEFFICIENT OF DRY MATTER WITH SHEEP, USING CHROMOGEN AND FECAL NITROGEN TECHNIQUES

Day	Time of Sampling	Sheep A		Sheep B		Sheep C		Average for Three Sheep	
		Chromogen Technique	Nitrogen Technique	Chromogen Technique	Nitrogen Technique	Chromogen Technique	Nitrogen Technique	Chromogen Technique	Nitrogen Technique
		%	%	%	%	%	%	%	%
I	8 A.M.	70.8	72.1	70.6	69.6	67.9	70.0	69.7	70.6
	1 P.M.	70.6	71.2	72.5	71.8	69.9	70.4	71.0	71.1
	5 P.M.	70.8	71.1	71.7	71.3	68.3	70.9	70.3	71.1
II	8 A.M.	72.2	70.9	68.5	69.8	74.1	74.9	71.6	71.9
	1 P.M.	72.6	70.8	72.3	70.6	69.6	71.0	71.5	70.8
	5 P.M.	73.5	70.7	72.3	71.7	68.8	67.4	71.5	69.9
III	8 A.M.	70.3	72.4	69.4	70.6	69.5	71.1	69.7	71.3
	1 P.M.	69.8	71.6	72.1	71.7	69.0	71.1	70.3	71.4
	5 P.M.	72.0	71.4	72.4	71.5	69.3	67.4	71.6	70.1
IV	8 A.M.	69.5	70.2	69.7	71.8	71.8	66.8	70.3	69.6
	1 P.M.	70.3	70.2	70.9	68.1	70.5	68.9	70.6	69.1
	5 P.M.	69.9	70.4	69.1	67.7	68.2	66.5	69.1	68.2
Average for four days	8 A.M.	70.7	71.4	69.5	70.5	70.8	70.7	70.3	70.8
	1 P.M.	70.8	70.9	69.5	70.6	69.8	70.4	70.0	70.6
	5 P.M.	71.6	70.9	71.5	70.6	68.7	68.0	70.6	69.8

Average and standard deviation of all samples: Chromogen technique are 70.8 and 2.89, respectively; Fecal Nitrogen technique are 70.4 and 3.08, respectively.

equations developed by Reid *et al.* (1952). These coefficients are very uniform and do not show variations as great as might have been expected from the fecal values of chromogen (figure 2). The explanation for this is that, in the formula used for determining the digestibility of dry matter, the chromogen content of the forage is not determined directly but is based on its level in the feces.[4] The chromogen content of different parts of a plant and of plants in different parts of the same plot is variable (Woolfolk, 1950) and animals are known to consume

[4] $Y=(0.0925\ X+137.3\ \log X)-242.12$, where Y=units of chromogen per gram of forage (dry basis), and X=units of chromogen per gram of feces (dry basis).

different parts of a plant in a day without following a definite pattern. Thus, the variation in the chromogen content of the feces collected at different times of the day seems quite logical. This means that a sample obtained by plucking the forage at any time of the day does not represent the forage consumed by the animal for the whole day.

TABLE 2. DIGESTION COEFFICIENT OF DRY MATTER WITH HEIFERS, USING CHROMOGEN TECHNIQUE

Day	Time	Heifer Number						Average for Six Heifers
		501	505	522	527	528	532	
		%	%	%	%	%	%	
I	8 A.M.	68.1	70.5	68.9	67.3	61.5	54.9	65.2
	1 P.M.	....[1]	....[1]	....[1]	....[1]	....[1]	....[1]	....[1]
	5 P.M.	68.1	72.5	67.8	70.5	65.6	67.9	68.7
II	8 A.M.	66.7	70.1	71.5	72.5	68.4	70.7	69.9
	1 P.M.	64.6	68.2	69.1	71.7	67.9	69.8	68.5
	5 P.M.	66.0	72.2	63.8	70.5	66.2	63.8	67.1
III	8 A.M.	66.0	59.8	64.6	68.0	64.2	64.3	64.5
	1 P.M.	63.2	67.5	66.3	69.9	65.8	65.1	66.3
	5 P.M.	64.7	68.3	65.0	68.3	64.5	65.1	66.1
Average	8 A.M.	66.9	66.8	68.3	69.3	64.7	63.3	66.6
for	1 P.M.	63.9	67.8	67.7	70.8	66.9	67.3	67.4
3 days	5 P.M.	66.3	71.0	65.5	69.8	65.4	65.6	67.3

Average and standard deviation of all samples are 67.1 and 2.73, respectively.

[1] No collection was made.

Kane *et al.* (1953b) have noted a 130 percent recovery of plant pigments in the feces as compared with those present in the forages, but "the application of Reid's formula to the data gave digestibilities in agreement with the total collection procedure." Thus, the use of the formula developed by Reid *et al.* (1952), which is based on a large number of well controlled experiments, seems to be the only practical way of determining the chromogen content of the forages actually consumed by the animal.

The similarity of average digestion coefficients obtained by the use of chromogen (70.3) and nitrogen (70.4) methods is in agreement with the results of Schneider *et al.* (1953). Although Forbes (1949) did not obtain satisfactory results by the use of fecal nitrogen as an indicator, still the simplicity and convenience of this method in the light of present studies calls for further work using this indicator.

Conclusions

The results of this study show that when the digestibility of the dry matter of forages consumed by grazing sheep and cattle is determined by the use of formulae developed by Reid *et al.* (1952) for chromogen, and by Lancaster (1949) for nitrogen, there is no diurnal variation in the estimates of digestibility.

Moreover, the fecal-nitrogen method appears to give as good an indication of dry matter digestibility as the chromogen method.

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A SURVEY OF THE EFFECT OF PHENOTHIAZINE ON UPTAKE OF RADIOIODINE BY THE THYROIDS OF FARM ANIMALS

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THE suppression of I^{131} uptake in the thyroids of rats fed phenothiazine was first observed by Talmage *et al.* (1953). Confirmation of this effect in the burro was subsequently reported (Talmage *et al.*, 1953b) with the additional indication that the purified form of the drug did not produce this antithyroid effect. On account of the widespread use of commercial phenothiazines in the livestock industry, it seemed important to determine the possible effects in various species. The data presented here represent the initial findings and are reported at this time to call attention to the problem.

Experimental Procedure

The animals used in this study were raised under ordinary farm conditions and had not been treated with phenothiazine or any other drug for a considerable period of time prior to the experiment. In sheep, steers, and burros the phenothiazine was administered orally by means of gelatin capsules. For swine and fowl it was mixed with the feed and the animals were permitted to eat *ad libitum*. The preparations, designated herein by letter, were commercial samples either purchased on the market or supplied by the manufacturer. At the designated time interval after starting the administration of phenothiazine, the animals were injected intraperitoneally with a solution of essentially carrier-free radioactive iodine (I^{131}). After 24 hours the chicks and hens were sacrificed and the thyroid dissected out for direct measurement of radioactivity. In the other animals *in vivo* measurements were made by means of a scintillation counter held over the thyroid. In all cases the control animals, which received no phenothiazine, were handled and measured in identically the same way as the test animals. The data were calculated as the percent reduction of the radioactivity in the thyroids of the experimental animals relative to those of the controls.

Results

The data are presented in table 1. It will be noted that in no case did the purified phenothiazine cause a suppression of I^{131} uptake.

[1] Oak Ridge Institute of Nuclear Studies research participant from Rice Institute, Houston, Texas.
[2] Agricultural Research Program, Oak Ridge, Tenn.

And although there are insufficient numbers to provide comparative potency values for the other preparations used, it was observed that sample A showed no effect on the burros but did have an effect on sheep. This difference may have been a consequence of the larger

TABLE 1. EFFECT OF PHENOTHIAZINE ON THE UPTAKE OF RADIOIODINE BY THE THYROIDS OF FARM ANIMALS

Species	Phenothiazine Preparation	Daily Dose (Grams)	Number of Animals	Number of Days Fed	Percent Reduction in I^{131} Uptake
Week-old-chicks	D	0.2% diet	4	3	93
	D	0.05% diet	18	3	80
	Controls	....	18	..	0
Hens	Purified	0.5% diet	2	10	0
	D	0.5% diet	2	3	65
	Controls	....	2	..	0
Sheep	Purified	3	2	10	0
	A	3	2	10	75
	B	3	2	3	90
	D	3	2	3	70
	Controls	..	4	..	0
Hogs	D	2	2	3	25
	D	2	1	4	30
	Controls	..	3	..	0
Steers	Purified	10	2	3	0
	B plus D	20	1	3	90
	D	10	2	3 hr.	50
	Controls	..	3	..	0
Burros	Purified	10	4	3	0
	A	5	3	3	0
	B	5	1	3	40
	C	5	2	3	95
	D	5	6	3	75
	D	5	4	3 hr.	35
	C plus D	5	1	2	90
	Controls	5	7	..	0

relative dose and longer treatment time used with sheep. Samples B, C, and D all were about of equal effectiveness. Of the species studied, swine appeared to be the least affected.

Discussion

The measurement of radioiodine uptake by the thyroid has been used extensively and satisfactorily as an index of overall thyroid function. However, it must be remembered that, in reality, thyroidal ac-

cumulation of iodine is but one of a number of mechanisms involved in the elaboration and metabolism of the thyroid hormone. Therefore, the reduction in I^{131} uptake caused by phenothiazine, although indicative, must not be considered indisputable proof of the existence of a truly hypothyroid condition. For instance, many commercial phenothiazine preparations are known to contain appreciable amounts of organic iodide. If this iodide were readily liberated, one would expect less of the injected I^{131} to enter the thyroid, partially because the dose would then be diluted with non-radioactive iodide and partially because the iodine collecting mechanism of the thyroid might be saturated. Whether or not this excess iodide would result in a reduced output of total thyroxine is, as yet, a debatable point. In any case, it is evident that it must have been the impurities in the preparations used—whether loosely bound organic iodide or unknown antithyroid compounds—which were responsible for the observed suppression in thyroidal I^{131} uptake, since it was shown in table 1 that purified phenothiazine had no effect.

Until more is known concerning the effect of excess iodide on the function of thyroid glands in normal animals, or the presence of an antithyroid compound in crude phenothiazine is unequivocally established, the practical aspects of this problem cannot be considered. Among the points now under active investigation are: (a) the nature of the impurities and the mechanism of their action and (b) the existence and extent of hypothyroidism which may be produced by present practice with phenothiazine preparations now on the market.

Summary

Attention is called to the fact that the feeding of some commercial phenothiazine preparations results in a reduced thyroid uptake of injected radioiodine in poultry, sheep, swine, cattle and burros, and that this effect may be indicative of an induced hypothyroidism.

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A STUDY IN VARYING COTTONSEED CAKE LEVELS IN A BEET-BELT STEER-FATTENING RATION

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Holly Sugar Corporation [2]

THE purpose of this study was to examine cottonseed cake in a typical beet-belt ration. A survey indicated that many steer-fattening rations contained protein supplements in amounts which brought the total digestible protein to levels far above those recommended by the National Research Council (Guilbert *et al.*, 1945). The usual protein supplement in the Western beet pulp areas is cottonseed cake. The question arose as to whether the extra cottonseed supplement provided faster gains or better finish.

Procedure

Experiment 1

Long yearling Hereford steers were fed at Hawk Springs, Wyoming, from November 4, 1951, to March 5, 1952, with three levels of cottonseed supplement added to a beet-belt ration.

The "high protein" ration, after the steers were on full feed, consisted of 1.5 lb. of 43% cottonseed cake, 6 lb. of ground corn, 3 lb. of molasses, 5 lb. of chopped alfalfa hay, and 60 lb. of pressed beet pulp. This ration has been standard throughout much of this area. The "medium protein" ration had 0.5 lb. less of cottonseed cake and 0.5 lb. more of corn. The "low protein" ration had 1.0 lb. less of cottonseed cake and 1.0 lb. more of corn, i.e., only 0.5 lb. of cake was fed to this pen. Salt and minerals were fed free choice.

Ten steers were fed per pen. Steers were selected from our commerical feed lot at Torrington, Wyoming, and matched as well as possible as to weight, conformation, and fleshing. Average steer weights were approximately 795 lb. Prior to the experiment the steers had been off range two weeks and were on a ration of wet pulp, alfalfa, cottonseed cake, and a little grain. The commercial pens used in this experiment provided 2,000 sq. ft. of space per animal. No bedding was provided.

[1] Thanks are due to Colorado Milling and Elevator Company for sharing in the costs of this investigation.

We wish to thank Roy Wiand, Roger S. Smith, Louis P. Orleans, and Alve Cole, of Holly Sugar Corporation, and William H Burkitt, of Colorado Milling and Elevator Company, for help in this study.

[2] Colorado Springs, Colorado.

Animals were weighed individually and ear-tagged and trucked 22 miles to Hawk Springs. At the end of the experiment the steers were again weighed individually so as to make possible statistical analysis of the data by the technique of analysis of variance (Snedecor, 1946). Since the steers were not fed to market finish at the end of the experiment, an experienced packer-buyer made estimates on slaughter value, dressing percentage and grade for each steer at the final weighing.

Experiment II

Long yearling Hereford steers were fed at Torrington, Wyoming, from November 25, 1952, to June 1, 1953, with four levels of cottonseed cake added to a beet-belt ration.

The steers were fed as in the first experiment, using wet pulp instead of pressed pulp. After the steers were on full feed, the daily ration for the "high protein" pen was 1.5 lb. of cottonseed cake, 4.5 lb. of chopped alfalfa, 6.0 lb. corn, 3.0 lb. molasses, wet beet pulp free choice (about 61 lb. average, but ranging from 75 lb. for green pulp early in the season to 56 lb. for ensiled pulp late in the feeding period). Salt and mineral were fed free choice.

The other three pens were fed identically except that the amount of cottonseed cake was lowered by 0.5 lb. in succeeding pens and compensating increments made in the corn. Thus, there were also "medium protein", "low protein", and "minimal protein" pens getting, respectively, 1.0 lb., 0.5 lb., and 0.0 lb. of cottonseed cake per head daily.

Twenty steers were fed in each experimental pen. The steers all came from the same ranch in New Mexico. The pens were filled by random-gate-cuts from the population of long yearlings from which had been removed sick or abnormally large and small animals. Each pen had animals ranging from 660 to 760 lb. Average weights for the pens ranged from 693 to 709 lb. Prior to the experiment the steers had been off range a month and were on a ration of wet pulp, alfalfa, and cottonseed cake. The experimental pens provided 150 sq. ft. of area per steer. Bedding was provided as required.

Initially the steers were weighed individually and branded with Roman numerals (from I to X) to give a record of each starting weight within five pounds. Thus final individual weights permitted analysis of variance for significance of weight gains.

During the course of the feeding trials, monthly weighings were made on each lot as a whole. At the final weighing, each steer was again weighed and ear-tagged. As soon as weighing was completed on a lot,

it was trucked to Swift and Co. in Gering, Nebraska. Off-truck weight for each lot was recorded at Swift.

The steers were slaughtered the following morning in the same lot sequence that they had been weighed, and individual records were kept on each steer.

Since individual weights could not be made at the packing house, the customary 4% shrink was applied to all Torrington weights. The shrunk weights were used in calculating net gains and dressing percentages. Payment was made on the basis of grade and dressing percentage and calculated back to a live weight value. This value is of interest since it combines the two determined criteria, dressing percentage and grade. Pen weights on and off truck gave a comparative picture of shrink in transit. This could not be analyzed statistically, since animals could not be weighed individually off truck at the packing house.

The packing house grader assigned numerical values to the grades of each carcass, thus permitting statistical comparison of the pens.

Daily aliquots from all feeds were combined monthly for periodic chemical analysis, except for molasses and pulp which were only sampled monthly. The average analyses are shown in table 3.

Results and Discussion

Experiment I

The pens are called "high", "medium", and "low" protein in this discussion for brevity rather than high, medium, and low cottonseed cake pens. It is not known how this series would have behaved with other protein supplements. Average daily gains for the high, medium, and low protein pens for the 121-day period were 1.74, 2.01, and 2.25 pounds, respectively. (See table 1.) The difference between the gains of the low and of the high protein pens was statistically significant. Total digestible nutrients and digestible protein were estimated from weights of feed and Morrison's values (Morrison, 1949). Obviously, T.D.N. (Total Digestible Nutrients) and digestible protein per 100 lb. of gain were least for the low protein pen. The saving in T.D.N. per pound of gain was 22.5%; digestible protein required for the low protein pen was 32.5% less than that required for the same gain in the high protein pen. The slaughter value based on estimations of dressing percentage and grade was higher for the low protein pen. This was an estimate by an experienced packer-buyer but could not be as accurate as the determinations reported for Experiment II.

It will be seen from table 1 that the estimated daily intake of digestible protein, even for the low protein pen, was generous since

TABLE 1. EXPERIMENT I—10 STEERS PER PEN FED 121 DAYS FROM NOVEMBER 4, 1952 TO MARCH 5, 1953

Type of Ration	"High Protein"	"Medium Protein"	"Low Protein"
Av. initial wt., lb. per steer	795	794	794.5
Av. final wt., lb.	1006	1037	1067
Av. total gain, lb.	211	243	273
Av. daily gain, lb.	1.74	2.01	2.25
Av. daily feed, lb.			
Alfalfa	5.12	5.49	5.10
Pressed pulp	62.15	61.16	61.98
Molasses	2.95	2.95	2.95
Corn	5.66	6.12	6.60
43% cottonseed cake	1.50	1.00	0.57
Salt	free choice	free choice	free choice
Mineral	free choice	free choice	free choice
Av. feed per cwt. gain, lb.			
Alfalfa	294.3	273.1	226.7
Pressed pulp	3571.8	3042.8	2754.7
Molasses	169.5	146.8	131.1
Corn	325.3	304.5	293.3
43% cottonseed cake	86.2	49.8	25.3
Salt (est'd.)	2.3	2.0	1.8
Mineral (est'd.)	2.3	2.0	1.8
Av. est'd. slaughter value	$31.45	$31.60	$32.75
Av. est'd. dressing percent	58.6%	58.7%	59.7%
Av. est'd. grade			
Choice, no. of steers	3	3	8
Good, no. of steers	6	6	2
Commercial, no. of steers	1	1	0
Est'd. dig. prot., lb.			
Daily	2.08	1.95	1.80
Per 100 lb. gain	120	97	80
Est'd. T.D.N., lb.			
Daily	16.75	16.81	16.77
Per 100 lb. gain	963	836	745
Est'd. nutritive ratio, 1:	7.05	7.62	8.32
LSD, 5% level—rate of gain	0.35		

the value of 1.8 lb. is above the 1.6 to 1.7 lb. recommended by the National Research Council (Guilbert *et al.*, 1945). Thus, in Experiment II, an attempt was made to reach a lower protein level.

Experiment II

Just as in Experiment I, steers in Experiment II gained at a significantly faster rate on the low protein compared to the high protein ration (table 2). The rate of gain was less for the minimal protein level

TABLE 2. EXPERIMENT II—20 STEERS PER PEN FED 188 DAYS FROM NOVEMBER 25, 1952 TO JUNE 1, 1953

Type of Ration	"High Protein" Ration	"Medium Protein" Ration	"Low Protein" Ration	"Minimal Protein" Ration
Av. initial wt., lb. per steer	699.5	700.5	692.8	709.0
Av. final wt. (less 4%), lb.	1069.9	1091.1	1096.6	1089.6
Net total gain, lb.	370.4	390.6	403.8	380.6
Net daily gain, lb.	1.97	2.08	2.15	2.02
Av. daily feed, lb.				
Chopped alfalfa	4.46	4.48	4.48	4.48
Wet pulp	60.48	62.18	62.82	61.24
Molasses	2.94	2.94	2.94	2.94
Corn	5.83	6.29	6.76	7.25
43% cottonseed cake	1.47	0.99	0.51	
Salt (free choice)	0.025	0.039	0.041	0.042
Mineral (free choice)	0.047	0.050	0.049	0.050
Av. feed per cwt. gain, lb.				
Alfalfa	226.6	215.8	208.8	221.5
Wet pulp	3069.6	2993.0	2924.5	3025.2
Molasses	149.0	141.3	136.7	145.0
Corn	295.9	302.8	314.9	358.0
43% cottonseed cake	74.8	47.8	23.5	
Salt (free choice)	1.28	1.86	1.92	2.07
Mineral (free choice)	2.39	2.39	2.26	2.46
Market value per cwt.	**$22.25**	**$22.25**	**$22.15**	**$21.85**
Actual shrink to market	2.49%	2.29%	2.69%	3.11%
Dressing percent	62.78%	62.73%	62.40%	61.65%
U. S. grade (before and after ribbing)				
High choice, no. of steers	4—6	3—7	4—5	2—6
Med. choice, no. of steers	16—14	17—13	16—15	18—14
Low choice, no. of steers	0—0	0—0	0—0	0—0
Est'd. dig. prot., lb.				
Daily	1.94	1.81	1.66	1.49
Per 100 lb. gain	98.6	87.0	77.3	73.4
Est'd. T.D.N., lb.				
Daily	15.14	15.32	15.41	15.30
Per 100 lb. gain	768.6	737.7	717.5	755.8
Est'd. nutritive ratio, 1:	6.94	7.46	8.28	9.27

LSD, 5% level—rate of gain 0.16; dressing % 0.85; Market value 0.37.

compared to the low protein level. The difference missed being statistically significant, however. The gains for high, medium, low and minimal rations were 1.97, 2.08, 2.15, and 2.02 pounds per head per day, respectively.

In Experiment II the low protein pen required 6.6% less T.D.N. and 21.6% less digestible protein per lb. of gain than did the high protein ration. In this area, of course, protein is the most expensive component of the ration.

No significant differences were found for dressing percentages in the first three pens; however, the dressing percentages of steers fed

TABLE 3. ANALYSES OF FEEDS USED IN EXPERIMENT II AVERAGED OVER THE FEEDING PERIOD

Type of Ration	Dry Matter	Protein	Fat	Fiber	Ash	N.F.E.	Est'd. Dig. Prot.[1]	Est'd. T.D.N.[1]
Alfalfa	93.49	11.59	2.04	36.77	8.10	35.63	8.23	50.66
Wet pulp	11.65	1.62	0.34	4.90	0.57	4.22	0.89	8.62
Corn	89.97	8.95	3.81	2.28	2.74	72.19	6.89	83.05
Molasses	74.01	4.78			7.18	62.05	2.49	58.96
43% cotton-seed cake	94.57	45.95	5.76	11.60	6.58	24.68	38.14	74.35

[1] Digestible protein and T.D.N. were calculated from Morrison's coefficients of digestibility.

a minimal protein ration were significantly lower than those of the first two pens. No significant differences were found for grades between the pens, either initial grades or grades after ribbing. A statistical analysis of the market value data revealed no significant difference among the first three pens. The value of the steers from the minimal protein pen was significantly lower than high and medium pens. Evidently the level of digestible protein (1.49 lb. per head per day) in the minimal protein pen was below optimum. This was the only pen with values below the National Research Council recommendations.

It is interesting to note that only 0.16 lb. gain difference was needed for significance in Experiment II where twenty steers were used per pen, while 0.35 lb. was needed for significance in Experiment I where only ten steers were used.

The two experiments suggest that not only is the use of excess cotton-seed cake wasteful, but its use can lead to lower gains without benefit of increased finish.

Summary

Various levels of cottonseed cake supplementation were studied in connection with a standard beet-belt ration of beet pulp, alfalfa and grain. In these studies one-half pound of cottonseed cake was found optimum in balancing the ration. Higher amounts of cottonseed cake resulted not only in slower but more expensive gains. Higher amounts of cottonseed did not improve dressing percentage, grade, or market value significantly. Elimination of cottonseed cake from the ration decreased market value and dressing percentage and did not increase economy of gain over the one-half pound level of this supplement.

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A STUDY OF THE SUPPLEMENTAL FEEDING OF CAROTENE FOR RANGE BREEDING COWS DURING THE PRECALVING AND CALVING PERIOD [1]

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A STUDY of the composition of range grasses in southern New Mexico from 1936 to 1941 (Watkins, 1943) showed that the mesa dropseed, one of the important grasses in the area, loses its carotene when it dies after frost, while black grama, one of the most important grasses, holds its carotene well during the winter. Some grasses remain partly green during the winter, and many plants, such as chamiza, mustards, and yucca, provide a wintertime source of carotene.

Riggs (1940) reported that it may take from two to five months to deplete cattle of their vitamin A reserves when they are fed a ration practically free of carotene. There was a question, however, in this area in southern New Mexico as to whether these range plants provide an adequate source of carotene during the winter for breeding cows.

A report from this station (Watkins *et al.*, 1950), states that the blood plasma carotene of Hereford range breeding cows during a five-year study was rather high, except for two years during the winter and spring months. The lower plasma carotene values for these two years raised a question as to whether there might be a carotene deficiency in certain years. To study the problem a new project was planned and put into operation. The objective of this new project was to determine the effect of supplementing dormant range with feed rich in net energy, digestible protein, and carotene. This paper will be concerned with the carotene and vitamin A in the blood of cows receiving the protein supplement plus carotene, compared with the carotene and vitamin A content of the blood of cows receiving the protein supplement with no added carotene.

Procedure

The pasture in which the feeding was done included 2470 acres with an excellent stand of black grama. Fifty grade Herefords, including

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aged cows and some first-calving heifers, were divided as evenly as possible into two groups based on age, weight, type, and previous production. Special steamed bone meal, mixed with an equal amount of salt, was available to the cattle at all times.

During the four weeks before calving, one group of 25 cows was fed one lb. of cottonseed meal per cow daily. The other group of 25 cows was fed 1¼ lb. of a mixture of 23 parts dehydrated alfalfa meal, 70 parts cottonseed meal, and 7 parts molasses. Feeding started about a month before the beginning of calving, usually about March 10. At the advent of calving, these daily amounts of supplements were doubled for both groups. Feeding was continued until there was a substantial amount of green feed. In favorable seasons, green feed was often available as early as the middle of April, but the feeding was never extended beyond early June.

The cows were weighed at the beginning of the experiment and at 28-day intervals during the feeding period. Carotene determinations were made on the alfalfa cubes and on the forage samples at 28-day intervals. On these sampling days, blood samples were taken from at least 12 and usually 16 representative cows in the lot receiving the cottonseed meal. An equal number of cows in the lot receiving the alfalfa cubes was bled. The blood samples were centrifuged in the field, placed in a portable refrigerator, and carried to the laboratory for analysis. Forage samples were gathered, using a system of portable hurdle pots which had been used previously at this station by Knox and co-workers (1941) in order to estimate the type of plants grazed and their degree of utilization. The forage carotene was analyzed by the petroleum ether-acetone method of Thompson and Bickoff (1951). The blood plasma carotene and vitamin A were determined by an adaptation of Kimbles' method, in which a photoelectric colorimeter was used. The vitamin A was determined by the antimony trichloride method and corrected for the amount of carotene present.

Results

The data obtained represent one sampling before calving, usually about March 15, and two samplings for the calving and later periods in April and May. The average carotene data, representing over 300 individual bleedings in each group, are presented in table 1.

Low forage carotene values are observed for March, 1948 and 1952, and also for April, 1951. The low forage carotene for March, 1952, was not accompanied by critically low blood carotene values. This

TABLE 1. AVERAGE PLASMA CAROTENE VALUES OF HEREFORD BREEDING COWS DURING THE PRECALVING AND CALVING PERIODS, AND RELATED DATA

Item	March	April	May
1946 Forage carotene [1]	22.1	22.0	24.9
Plasma carotene, cottonseed meal-fed cows [2]	288	653	582
Plasma carotene, alfalfa cube-fed cows	324	647	599
Added carotene from alfalfa cubes [3]	21.6	36.7	36.4
1947 Forage carotene	27.2	56.1	28.6
Plasma carotene, cottonseed meal-fed cows	651	642	603
Plasma carotene, alfalfa cube-fed cows	669	606	535
Added carotene from alfalfa cubes	9.6	23.8	23.8
1948 Forage carotene	6.4	22.5	35.2
Plasma carotene, cottonseed meal-fed cows	398	454	673
Plasma carotene, alfalfa cube-fed cows	390	499	741
Added carotene from alfalfa cubes	20.0	42.2	27.6
1949 Forage carotene	24.9	38.4	44.1
Plasma carotene, cottonseed meal-fed cows	133	342	808
Plasma carotene, alfalfa cube-fed cows	125	286	776
Added carotene from alfalfa cubes	8.8	19.6	19.6
1950 Forage carotene	10.2	16.2	21.8
Plasma carotene, cottonseed meal-fed cows	263	234	399
Plasma carotene, alfalfa cube-fed cows	257	219	345
Added carotene from alfalfa cubes	13.8	26.1	26.1
1951 Forage carotene		4.8	35.1
Plasma carotene, cottonseed meal-fed cows		205	234
Plasma carotene, alfalfa cube-fed cows		257	231
Added carotene from alfalfa cubes		14.0	23.2
1952 Forage carotene	1.5	25.8	38.8
Plasma carotene, cottonseed meal-fed cows	129	203	601
Plasma carotene, alfalfa cube-fed cows	142	197	586
Added carotene from alfalfa cubes	9.3	18.6	18.6
1953 Forage carotene	8.7	34.0	36.3
Plasma carotene, cottonseed meal-fed cows	182	845	868
Plasma carotene, alfalfa cube-fed cows	142	909	936
Added carotene from alfalfa cubes	27.0	51.7	45.6

[1] Forage carotene, mg. per lb., calculated on an air-dry basis.
[2] Plasma carotene in mcg. per 100 ml. of plasma.
[3] Alfalfa cube carotene, mg. per cow per day.

March sampling may not have been representative, and a resampling would have been desirable. With the exception of the 1952 forage carotene for March, a dry-matter intake of some 18 lb. of forage always provided a large excess of carotene over the 90 mg. which is the requirement for a cow suckling a calf. With a few exceptions, this

range forage had a carotene content ranging from that of good-quality alfalfa to nearly half the value of good dehydrated alfalfa meal.

The plasma carotene, according to the data in table 1, was generally low during March, but usually reached rather high levels as the young plants and grass appeared. Davis and Madsen (1941) reported that Hereford and Shorthorn cows with a level of 78 to 96 mcg. of carotene per 100 ml. of plasma produced normal calves; a higher level of carotene in the plasma was necessary for first-calving heifers. Payne and Kingman (1947) report that aged Hereford cows may have normal health and reproduction with 83 mcg. of plasma carotene, while a heifer should have at least 118 mcg. of carotene in the blood. An inspection of the plasma carotene for the cottonseed meal-fed cows in March of 1949 and 1952 showed carotene levels of 133 and 129 respectively. These were the lowest plasma carotene values found, but still there was a slight reserve above the requirement level of 118 mcg. The April, 1949, average was 258 percent above that of the March carotene level. The April, 1952, level was also 157 percent above the March value for that year. Among the May plasma carotene figures were values of from 500 to 900 mcg. These levels usually represent animals on good-quality pasture.

Among the alfalfa cube-fed cows, 310 animals were bled, with a mean of 453.0 mcg. of carotene per 100 ml. of plasma for the entire project. For the cottonseed meal-fed cows, 316 animals were bled, with a mean of 451.7 mcg. of carotene per 100 ml. of plasma. A statistical analysis of these data showed no significant difference in the plasma carotene of the alfalfa cube-fed cows over that of the cottonseed meal-fed cows. The feeding of the alfalfa cube, which furnshed 0.29 lb. of dehydrated alfalfa meal before calving and 0.58 lb. after calving, did not increase the blood plasma carotene of these cows over that of the cottonseed meal-fed cows. The carotene from the dehydrated alfalfa meal varied considerably from season to season, even though much care was taken to provide a high carotene meal.

According to the data in table 2, there was some variation in the vitamin A values, with the lower figures associated with the lower blood carotene. The plasma vitamin A, with only a few exceptions, fell within the range of 40 to 65 mcg., the amount presented by Davis and Madsen (1941) for animals on good pasture. Among the alfalfa cube-fed cows there were 310 animals bled, with a mean of 50.6 mcg. of vitamin A per 100 ml. For the cottonseed meal-fed cows, 316 animals were bled, with a mean vitamin A of 50.9 mcg. The statistical analysis

of these data showed no significant difference in the vitamin A value of these two groups.

TABLE 2. AVERAGE PLASMA VITAMIN A VALUES OF HEREFORD BREEDING COWS DURING THE PRECALVING AND CALVING PERIODS, AND RELATED DATA

	Item	March	April	May
1946	Forage carotene [1]	22.1	22.0	24.9
	Plasma vitamin A, cottonseed meal-fed cows [2]	45.4	55.7	54.7
	Plasma vitamin A, alfalfa cube-fed cows	45.2	53.3	54.2
	Added carotene from alfalfa cubes [3]	21.6	36.7	36.4
1947	Forage carotene	27.2	56.1	28.6
	Plasma vitamin A, cottonseed meal-fed cows	59.7	62.2	53.7
	Plasma vitamin A, alfalfa cube-fed cows	58.8	62.6	52.8
	Added carotene from alfalfa cubes	9.6	23.8	23.8
1948	Forage carotene	6.4	22.5	35.2
	Plasma vitamin A, cottonseed meal-fed cows	57.8	65.3	60.8
	Plasma vitamin A, alfalfa cube-fed cows	57.0	67.1	63.4
	Added carotene from alfalfa cubes	20.0	42.2	27.6
1949	Forage carotene	24.9	38.4	44.1
	Plasma vitamin A, cottonseed meal-fed cows	39.8	49.4	51.7
	Plasma vitamin A, alfalfa cube-fed cows	38.3	47.6	48.3
	Added carotene from alfalfa cubes	8.8	19.6	19.6
1950	Forage carotene	10.2	16.2	21.8
	Plasma vitamin A, cottonseed meal-fed cows	57.9	47.0	41.3
	Plasma vitamin A, alfalfa cube-fed cows	54.0	45.4	37.3
	Added carotene from alfalfa cubes	13.8	26.1	26.1
1951	Forage carotene		4.8	35.1
	Plasma vitamin A, cottonseed meal-fed cows		31.6	42.9
	Plasma vitamin A, alfalfa cube-fed cows		39.2	48.3
	Added carotene from alfalfa cubes		14.0	23.2
1952	Forage carotene	1.5	25.8	38.8
	Plasma vitamin A, cottonseed meal-fed cows	53.9	40.6	43.7
	Plasma vitamin A, alfalfa cube-fed cows	50.5	41.9	46.3
	Added carotene from alfalfa cubes	9.3	18.6	18.6
1953	Forage carotene	8.7	34.0	36.3
	Plasma vitamin A, cottonseed meal-fed cows	40.9	55.7	60.0
	Plasma vitamin A, alfalfa cube-fed cows	40.3	55.0	57.1
	Added carotene from alfalfa cubes	27.0	51.7	45.6

[1] Forage carotene, mg. per lb., calculated on an air-dry basis.
[2] Plasma vitamin A in mcg. per 100 ml. of plasma.
[3] Alfalfa cube carotene, mg. per cow per day.

It appears likely that the high carotene content of the forage in southern New Mexico was sufficient to maintain the blood carotene and vitamin A of breeding cows at a level meeting the animals' require-

ments so that the feeding of additional carotene, as in a dehydrated alfalfa meal supplement, did not increase the respective blood values.

Summary

Two groups of grade Hereford cows were grazed on dormant range typical of southern New Mexico and given supplemental feed during the pre-calving and calving periods. The energy and the digestible protein of the supplemental feed were approximately the same for both groups, but one group received additional carotene from dehydrated alfalfa meal.

The blood carotene of the cows fed cottonseed meal was well above the requirements as shown by various workers, indicating no major deficiency over an eight-year period even in the most critical season.

An important observation of this project is that the feeding of the mixture, containing 23 percent dehydrated alfalfa meal, did not raise the plasma carotene over that of the cows fed no extra carotene. There was no significant difference in the plasma carotene and vitamin A results for the two groups.

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CREATININE EXCRETION AND SPECIFIC GRAVITY AS RELATED TO THE COMPOSITION OF THE 9, 10, 11th RIB CUT OF HEREFORD STEERS

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EVIDENCE has been accumulated showing that in general urinary creatinine excretion is related to body weight or to the lean tissue of the animal body (Brody, 1945). Dinning *et al.* (1949) found that the creatinine excretion of individual beef steers was not affected by protein intake and was relatively constant from day to day when compared to differences between individual steers. Since one would not expect the lean tissue of an animal to change markedly from day to day but would expect differences to occur between individuals, this work indicates creatinine excretion may be of value in predicting differences in the lean tissue of animals. Recently Miller and Blyth (1952) found that the lean body mass of individual humans predicted from creatinine excretion agreed within 13.1 percent of the densiometrically determined value in 90 percent of the cases. For groups of 50 or more, the prediction agreement was within 2.0 percent in 90 percent of the cases. Since it is often desirable to have some knowledge of differences in the protein content of the bodies of living animals, a study was designed to determine the correlation between creatinine excretion and the lean content of the carcass of beef steers. The separable lean of the 9, 10, 11th rib cut was used as in indication of the lean of the entire carcass since Hankins and Howe (1946) have shown the lean of this sample is highly correlated ($r=0.90\pm0.01$) with that of the entire carcass of beef steers. A second purpose of the study was to determine if the fat content of the 9, 10, 11th rib cut could be accurately predicted from specific gravity determinations. If this were possible, the time and labor involved in mechanically separating the fat from the other tissue could be eliminated.

Experimental

Eighteen head of long-yearling Hereford steers were divided at random into two lots of nine head each. One lot was full-fed a ration

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consisting of 40 percent oat hay, 43 percent ground barley, 12 percent dried beet pulp, 4 percent cottonseed meal, 0.5 percent oyster shell flour and 0.5 percent sodium chloride. The second lot was full-fed the same ration with the exception that the 4 percent cottonseed meal was replaced by 3.8 percent dextrose and 0.2 percent monobasic potassium phosphate. The two rations were fed in an effort to obtain information on the protein requirements of fattening steers while obtaining the information on creatinine excretion. The data on protein requirements will be reported at a later date.

Prior to being slaughtered, each steer was fed oat hay alone for a period of 12 days. During the last 5 days total urine was collected and analyzed for creatinine by the picric acid method (Hawk *et al.*, 1947). After slaughter each carcass was graded and the 9, 10, 11th rib cut taken from the right side by the method of Hankins and Howe (1946). The specific gravity of the whole cut was determined by weighing in air and in water. Each sample was then manually separated into fat, lean and bone and the specific gravity of each of the separable constituents determined as in the case of the whole cut. Because of the limitations in the number of urine collections which could be made at one time and the length of time required to make the desired measurements on each rib sample groups of only three or four steers were slaughtered at one time. The first group was slaughtered after 94 days and the last group after 154 days on feed.

Results and Discussion

The creatinine excretion and the percent separable lean in the soft tissue of the 9, 10, 11th rib cut are shown in table 1. The two measures are significantly correlated ($r=0.67$). For purpose of comparison the data are divided into two groups of equal numbers on the basis of creatinine excretion. The lean content of the group having the higher creatinine excretion is highly significantly greater than that of the group having the lower creatinine excretion. It is interesting that of the nine steers falling in group 1 with the lower creatinine coefficients, eight yielded carcasses of choice grade with the other one grading good. Of the nine steers in group two having the higher creatinine coefficients, four were choice, four good and one commercial. The commercial steer had the highest creatinine coefficient and also the highest percentage lean of any of the 18 steers. The mean creatinine coefficients of the choice, good and commercial steers were 27.6, 31.1 and 37.3

and the mean lean percentages were 56, 62 and 69 respectively. Although the correlation coefficient is probably not high enough to enable one to predict small differences between individual animals, it does appear possible that creatinine excretion may be useful as an indication of differences in the lean content of the bodies of groups of animals differing by one or more slaughter grade. Since all animals in this experiment graded good or choice except one, it would be of

TABLE 1. CREATININE EXCRETION AND THE PERCENT LEAN IN THE SOFT TISSUE OF THE 9, 10, 11th RIB CUT

	Group 1		Group 2	
	Creatinine Coefficient [1]	Separable Lean	Creatinine Coefficient [1]	Separable Lean
		percent		percent
	24.3	53	28.1	62
	24.9	52	29.5	55
	25.1	56	29.9	62
	25.6	63	30.2	64
	26.6	57	30.4	57
	27.1	55	31.4	60
	27.2	58	35.8	61
	27.6	53	35.9	61
	27.8	58	37.3	69
Means	26.2	56	32.0	61**

[1] Milligrams creatinine per kilogram body weight.
** Highly significant.

value to establish the relationship between creatinine excretion and lean body mass in animals of other grades. It is possible that over the range of body composition which would be representative of the various grades, creatinine excretion may be rather closely related to lean body mass.

In the estimation of the fat content of a body or of a representative sample of that body from specific gravity, it is necessary to know the specific gravity of the fat and of the fat-free body. The mean specific gravities of the various components of the rib cuts used in this study are presented in table 2. For comparative purposes the corresponding values for humans as found by Behnke *et al.* (1942) are also included. The relatively good agreement between these two sets of values is noteworthy. Using the values listed in table 2 for the specific gravity

TABLE 2. COMPARISON OF THE SPECIFIC GRAVITY OF CONSTITUENTS OF THE BODY OF STEERS AND HUMANS

Constituent	Steers		Humans [1]
	mean	S.E.	
Fat	0.894	0.002	0.94
Lean	1.065	0.001	1.060
Bone	1.55	0.01	1.56
Fat-free body	1.155	0.002 [2]	1.10

[1] Behnke *et al.* (1942).

[2] Calculated from the formula $G_{ff}=\frac{G_w-(G_f\times F)}{1-F}$ where G_{ff} is the specific gravity of the fat-free cut, G_w is the specific gravity of the whole cut, G_f is the specific gravity of the fat and F is the proportion of separable fat in the cut.

S.E.—standard error.

of the fat and of the fat-free cut, the specific gravity of the whole cut can be represented

$$(1) \qquad G_w=0.894\ F+1.155\ (1-F)$$

where G_w is the specific gravity of the whole cut and F is the proportion of separable fat in the cut.

Equation (1) can be rewritten:

$$(2) \qquad F=\frac{1.155-G_w}{0.261}$$

It is evident from equation (2) that the separable fat can be calculated if the specific gravity of the whole cut is known.

A comparison of the separable fat as determined by mechanical

TABLE 3. THE SEPARABLE FAT OF THE 9, 10, 11th RIB CUT AS DETERMINED BY MECHANICAL SEPARATION AND FROM SPECIFIC GRAVITY

Specific Gravity of Whole Cut	Percent Separable Fat	
	Mechanically Separated	Estimated from Specific Gravity
1.049	38.5	40.6
1.050	41.1	40.2
1.052	40.4	39.5
1.055	37.4	38.3
1.057	36.5	37.5
1.058	39.5	37.2
1.059	37.1	36.8
1.060	33.5	36.4
1.065	34.8	34.5
1.069	33.5	33.0
1.071	31.5	32.2
1.081	26.1	28.4

separation and as calculated from equation (2) is presented in table 3. The two sets of values are in good agreement (r=0.93). It appears, therefore, that the fat content of the 9, 10, 11th rib cut of steer carcasses can be accurately estimated from the specific gravity of the whole cut. Because of the difficulty of obtaining complete separation of the fat from the other tissues, the value calculated from specific gravity may be even more accurate than that determined by mechanical separation and certainly saves considerable time. Since there is little variation in the values listed in table 2 for the specific gravity of the fat and the fat-free cut, it is probable that equation (2) could be used in future studies to predict the separable fat content of the 9, 10, 11th rib cuts of beef steers.

Summary

Creatinine excretion and the separable lean content of the 9, 10, 11th rib cut of 18 Hereford steers have been determined. The creatinine excretion per unit of body weight was significantly correlated with the percent separable lean in the soft tissue of the sample (r=0.67). It was found that while there appeared to be little correlation between these two measures within carcass grades, the correlation between grades was good.

The separable fat of the rib sample can be predicted accurately from the specific gravity of the whole sample by use of the equation

$$F=\frac{1.155-G_w}{0.261}$$

where F is the proportion of separable fat in the rib cut and G_w is the specific gravity of the whole cut.

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A MODIFIED LIGNIN PROCEDURE

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INTEREST in the lignin content of feedstuffs has increased with the improvement in methods for its determination. The determination of lignin by the usual methods is empirical and the range of values may be large with relatively minor changes in procedure (Thomas and Armstrong, 1949). Ellis, Matrone and Maynard (1946) developed a procedure that gives consistent results and has been widely accepted. Forbes and Hamilton (1952) have modified this method with a sodium carbonate treatment that reduces the nitrogen content of the isolated crude lignin. The modifications of the Ellis, Matrone and Maynard (1946) method suggested here reduce the number of transfers and introduce the use of an autoclave in place of refluxing to shorten the length of time and work required to carry out the determination.

With the exception of the sodium carbonate treatment, the modified procedure has been used in this laboratory for several years with excellent results. The reagents and sequence of their use are the same as in the original procedure. The procedure with suggested modifications is as follows:

1. Weigh a 1 gm. sample directly into a 250 ml. Erlenmeyer flask.
2. Cover the sample with 20–30 ml. of an ethanol-benzene mixture and let stand for 30 to 60 minutes. Filter. Repeat until no more pigment is extracted. The filter stick is left in the flask for the remainder of the procedure. Filter aid may be used as needed.
3. Wash with alcohol and ether. Remove the residual ether by heat or sucking air through the sample with the filter stick.
4. Add 40 ml. of a 1 percent pepsin solution in 0.1N HCl. Incubate overnight at 40° C. It is not necessary to cover the flasks.
5. Filter off the pepsin solution and wash with hot water.
6. Add 100 ml. of 0.25 percent Na_2CO_3 solution. Incubate overnight at 40° C.
7. Filter and wash with hot water.
8. Add 150 ml. of 5 percent (1N) H_2SO_4 and autoclave for 10 minutes at 20 lb. pressure. If an autoclave is not available, solution

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may be boiled on hot plate for 1 hour, adding water as needed to maintain the volume.

9. Filter and wash with alcohol and ether. Remove ether.

10. Add 20 ml. of 72 percent (23.4N) H_2SO_4. Digest for 2 hours at room temperature (20 to 23° C.).

11. Dilute, filter and wash.

12. Add 150 ml. of 3 percent (0.6N) H_2SO_4. Autoclave for 10 minutes at 20 lb. pressure.

13. Filter into a Gooch crucible. Wash free of acid. Determine the lignin by loss of weight on ashing.

Table 1 indicates the effect of the several suggested modifications

TABLE 1. PERCENT LIGNIN IN FEEDSTUFFS AND FECES WITH SEVERAL MODIFICATIONS IN PROCEDURE

Material		1	2	3	4	5
Dehydrated grass		8.18	8.06	8.10		
		8.10	8.12	8.02		
		8.19	8.01	8.06		
	Ave.	8.16	8.06	8.06		
Ration[a]			(5.25)	4.70	4.13	3.85
			4.81	4.81	4.02	3.87
			4.79	4.71	4.08	3.98
	Ave.		4.80	4.73	4.06	3.90
Rabbit feces			11.39	10.42	9.00	8.87
			11.33	10.63	9.01	8.70
			11.50	10.55	8.94	8.70
	Ave.		11.41	10.53	8.98	8.76

[1] Original procedure. (Ellis, Matrone and Maynard, 1946).
[2] Boiled on hot plate.
[3] Autoclaved at 20 lb. pressure for 10 minutes.
[4] Na_2CO_3 and hot plate.
[5] Na_2CO_3 and autoclave.
[a] 75% dehydrated grass with 20% cerelose and 5% fat.

on the lignin content of feedingstuffs and rabbit feces. The use of the autoclave or hot plate yields slightly lower values than the original procedure, with autoclaving lower than the hot plate. The difference between the use of the hot plate and the autoclave is greater in feces than in the feed. The introduction of a sodium carbonate treatment lowers the apparent lignin values approximately 18 percent in feedingstuffs and 20 percent in rabbit feces. On the basis of Forbes and Hamilton's (1952) work, this decrease probably reflects a reduced nitrogen content of the isolated crude lignin. The use of this treatment in the lignin determination should reflect with greater accuracy the true lignin content of these materials.

Summary

A modified procedure for the determination of lignin is presented which is faster and more convenient than the original procedure.

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A MODIFIED METABOLISM STALL FOR STEERS

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Oklahoma Agricultural Experiment Station [1]

MOST metabolism studies with large animals require quantitative measurement of feed intake and separate and accurate collection of feces and urine. Metabolism stalls and other equipment designed for this purpose have been described in recent years for use with sheep (Bratzler, 1951; Cook *et al.*, 1952), heifers and steers (Hobbs *et al.*, 1950) and cows (Balch *et al.*, 1951). Each of these, while adequate for the purpose, have certain objectionable features; therefore, in the construction and equipping of new facilities for metabolism studies at this station, it was deemed desirable to undertake the design, construction and testing of an improved device.

A metabolism stall of simple design, which has given satisfactory results with wethers during the past five years, was described by Briggs and Gallup (1949). A stall of similar design, except for method of urine collection, was less satisfactory for steers. In the stall for steers, urine was collected by means of a rubber funnel which was strapped to the animal and coupled to a rubber hose leading to a bottle beneath the stall floor. This arrangement, although generally satisfactory, required frequent attention to keep the harness and funnels in proper adjustment and repair. Broken connections and tears in the funnel resulted most frequently from the animal stepping on the hose. Further, the rigidity of the stanchion of the stall made it difficult for steers to lie down and get up. Pressure against the stanchion, especially when the animal was in a prone position, resulted in soreness and occasional edema in the neck region. These and other undesirable features have been eliminated in the design of a modified stall.

Description of Modified Steer Stall [2]

Modifications of the usual type of steer metabolism stall include: (1) all metal construction except for the floor, (2) provision for ready

[1] Departments of Animal Husbandry and Agricultural Chemistry Research, Stillwater, Oklahoma.

[2] The drawings were made by J. I. Fryrear, Department of Agricultural Engineering, and the photograph taken by R. H. Burley, Experiment Station Editorial Office. A description and photograph of an excellent all metal stall for sheep was furnished the authors by E. W. Crampton, MacDonald College, Quebec, Canada. The authors wish to acknowledge other correspondence, in connection with the construction of these stalls from M. C. Bell, Wise Burroughs, Harold Goss, T. S. Hamilton, C. S. Hobbs, E. W. Klosterman, J. K. Loosli and R. W. Swift.

adjustment of length of stall, (3) use of dairy-type stanchion which allows greater freedom of movement, (4) use of automatic water device, (5) greater clearance between floor of stall and base, and (6) provision for collection of urine by means of metal grid and funnel or by rubber funnel and hose. Twelve stalls have been constructed, and have been used in the new metabolism room of the Animal Husbandry

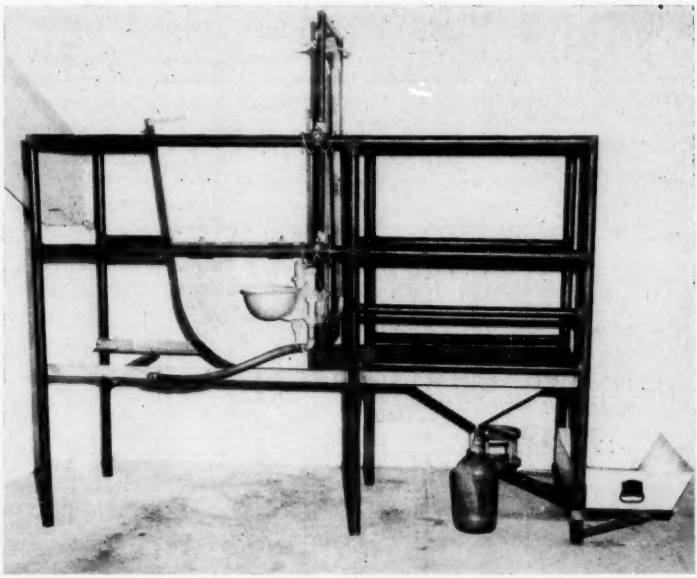

Figure 1. View of metabolism stall with metal grid and funnel for the collection of urine. The water cup has been turned out and the feed hopper is in position against the stanchion.

building for a period of 15 months with excellent results. Construction details are shown in figures 1 through 4.

Although the use of metal has increased the cost, such construction is stronger, and has other obvious advantages over wood construction. The framework is of welded pipe and angle iron. The floor, stanchion assembly, water cup, and feed hopper are detachable for easy cleaning or repair. The floor is coated with an abrasive paint to provide a surer footing for the animals (Hobbs, 1950).

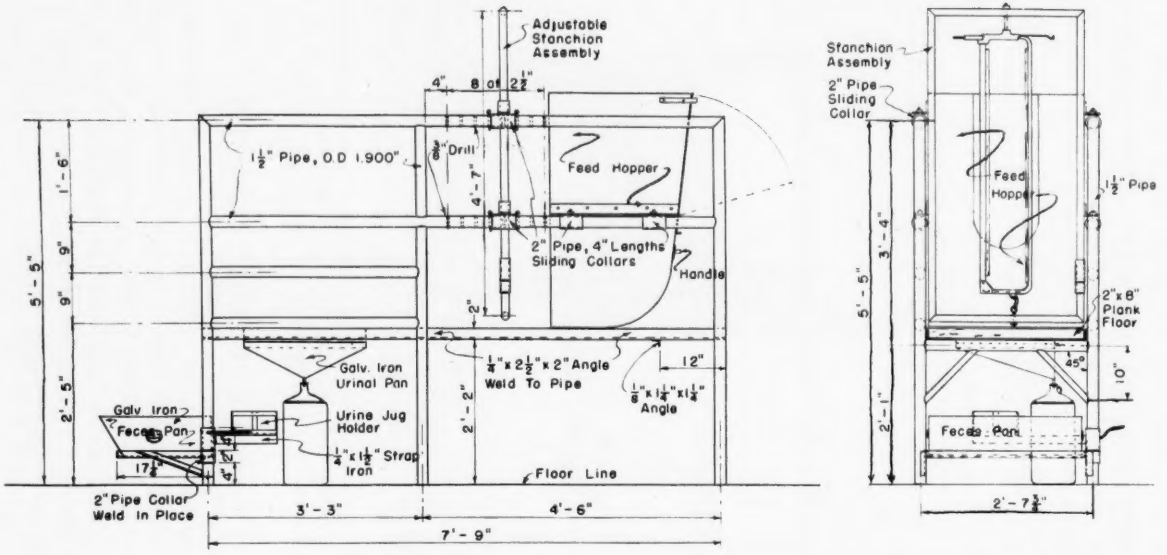
Adjustable Stanchion Assembly
4" & 8 at 2½"
1½" Pipe, O.D 1.900"
Drill
Feed Hopper
2" Pipe, 4" Lengths Sliding Collars
Handle
Galv. Iron Urinal Pan
¼" x 2½" x 2" Angle Weld To Pipe
12"
⅛" x 1¼" x 1¼" Angle
Galv. Iron Feces Pan
Urine Jug Holder
¼" x 1½" Strap Iron
Floor Line
2" Pipe Collar Weld In Place
3'-3"
4'-6"
7'-9"
5'-5"
1'-6"
9"
9"
2'-5"
4'-7"
2"
2'-2"
17½"
SIDE ELEVATION
Stanchion Assembly
2" Pipe Sliding Collar
Feed Hopper
1½" Pipe
2"x8" Plank Floor
45°
1'-0"
5'-5"
3'-4"
2'-1"
Feces Pan
2'-7½"
LEFT END ELEVATION

Figure 2.

The length of the stall may be adjusted by moving the stanchion assembly forward and backward as indicated in the drawings. The sliding pipe collar assembly allows easy movement. A bushing between the sliding collar and framework of the stanchion prevents binding.

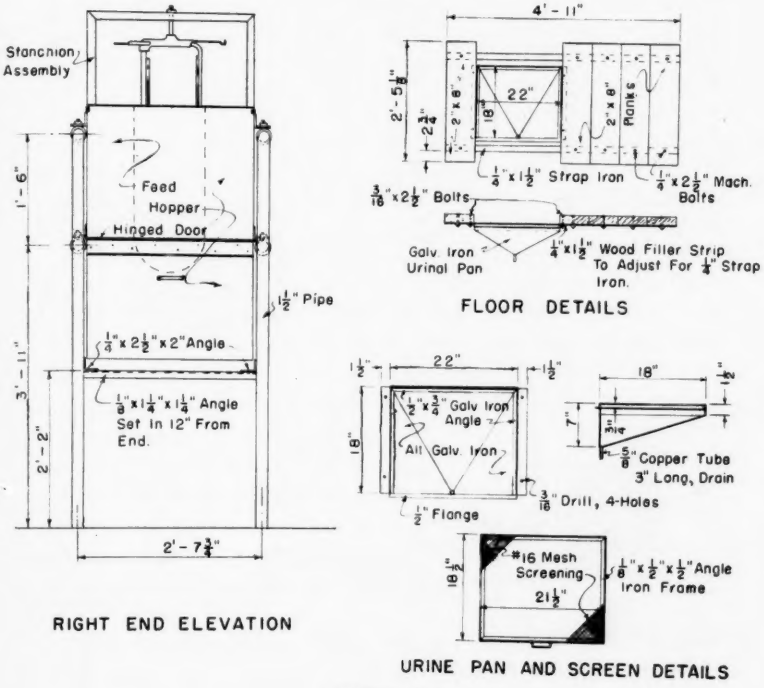

Figure 3.

The swinging dairy-type stanchion allows the animal considerable freedom of movement, it provides greater comfort than a rigid stanchion, and its flexibility makes it easy for the animal to lie down and get up.

The metal feed hopper slides forward away from the animal to allow the automatic water cup to be turned and locked in position. Feed and water are not available at the same time, consequently the feed and feed hopper are kept dry. Although no provision is made for measurement of water intake, a meter could be installed in the system. For ease in feeding, the upper half of the front side of the feed hopper

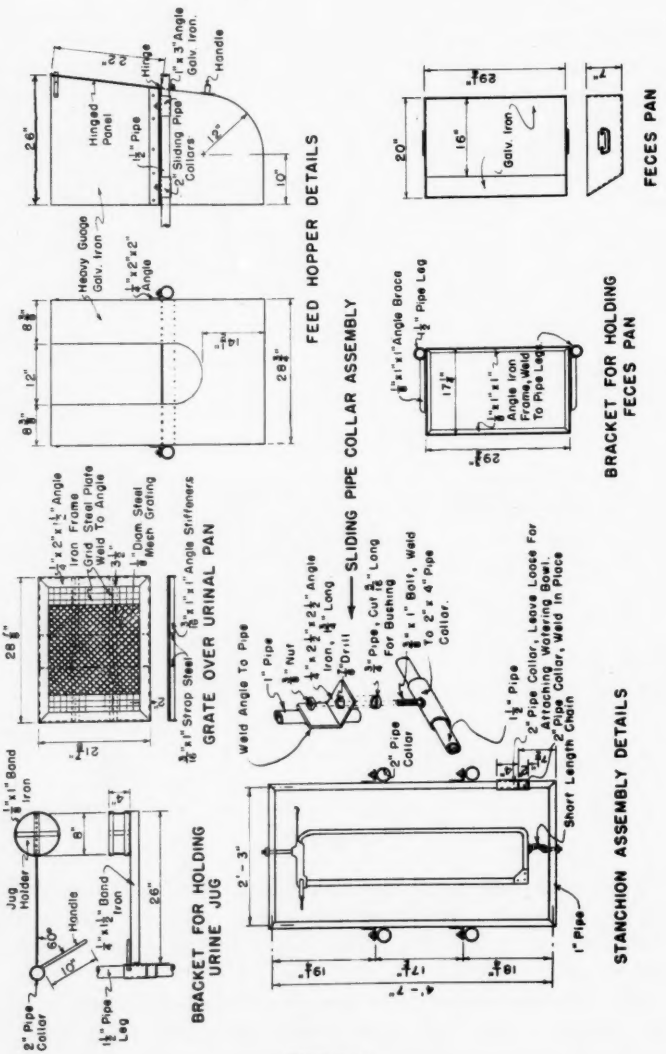

Figure 4.

is hinged. The lower front part is rounded to keep the feed within reach of the animal and prevent accumulation of feed in corners. A handle facilitates movement of feed hopper away from the animal.

The clearance between the stall floor and the base is sufficient to allow convenient collection of urine in a 2- or 3-gallon bottle. The wooden floor of the stall is so constructed as to allow collection of urine either with a rubber funnel and hose as previously described (Briggs and Gallup, 1949) or with a metal grid, fine mesh screen, and funnel as shown in the picture and drawings. The grid assembly and three floor boards are interchangeable. When the rubber funnel and hose are used, the urine collection bottle is placed in a metal holder which swings to the side of the stall for convenience in removal. A 1¼-inch hole in one of the floor boards accommodates the hose. A table clamp fastened to the hose just beneath the floor prevents the hose being pulled from the bottle. When the metal grid is used, the urine bottle is placed on the laboratory floor. The screen slides out to one side for effective cleaning.

The grid is made strong enough to support the weight of the animal by reinforcement with two strips of inverted angle iron. The large mesh of the grid is necessary to prevent loss of urine from splattering. The area of the fine mesh screen on which urine falls is surprisingly small. Since the sides of the collection pan are sloped, there is no occasion for urine to spread over a wide area; thus losses from evaporation or fermentation are minimized. In use, such losses are further reduced by frequent rinsing of the screens and pan with water, using a length of laboratory rubber tubing fitted with a spray nozzle and connected to a water cock on the intake pipe. This method of urine collection is most satisfactory where urine output is not being measured and metal contamination is not of consequence. It gives less trouble than rubber funnels and hose.

These stalls can be placed side by side in pairs to save floor space and to allow easy access to all steers. When so placed, the members of each pair must have both the water intake and urine outlet on opposite sides.

Feces drop in a metal pan located at the rear of the stall considerably below the level of the stall floor. With proper adjustment of stall length there is no loss of feces, and the steers soon learn to avoid stepping back and down. The feces are removed at frequent intervals during the day and placed in covered containers.

The stalls are of a size suitable for use with calves and yearlings. Stalls of larger dimensions, including increased space to accommodate a larger urine bottle, would be necessary for use with mature animals.

Summary

A modified metabolism stall for use in digestibility and nutrient balance trials with steers is described. The stall is built largely of metal for strength and durability, and has replaceable parts. It features a rounded metal feed box, a sliding, dairy-type stanchion which governs the length of the stall, an automatic watering device, and interchangeable floor pieces which permit collection of urine by means of a metal grid and funnel, or a rubber funnel and hose. The stall is illustrated by a photograph and drawings which give dimensions and details of construction.

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AN ANALYSIS OF THE COMPONENTS OF VARIANCE IN CALVING INTERVALS IN A RANGE HERD OF BEEF CATTLE [1]

LANS O. BROWN, RALPH M. DURHAM, ESTEL COBB and J. H. KNOX [2]

New Mexico Agricultural Experiment Station [3]

A CALVING interval is defined as the time elapsing from the date of birth of a cow's calf till the birthdate of her next calf. The calving interval comprises the interval from calving to first heat, number and length of estrus cycles, and length of gestation. Any practices designed to shorten the length and increase the constancy of the calving interval would be desirable.

Materials and Methods

The data used in this study were taken from the records on the Angus cattle at the El Sueco Ranch in Chihuahua, Mexico.

Under the system of breeding used at this ranch, a cow in heat was brought into a central bull barn, where she was bred by natural service to a selected bull. The recently-bred cow was then put into a pasture and observed for return to heat. If the cow returned to heat, she was bred again to a selected bull. After the non-return to heat indicated that the cows had settled, they were turned into a calving pasture with one bull. This procedure made certain that the cows were bred again if they had previously failed to conceive. Riders rode the range daily, eartagging and recording the birthdates of the calves. Each cow had previously been branded with a number. Calves were eartagged with numbers corresponding to those of their dams. The cows were bred the year round, so that random breeding and calving dates were obtained. Breeding was probably less seasonal than in dairy herds, inasmuch as a cow was bred as soon as she came in heat, whether one week or six weeks after calving. Each calving interval was rounded to the nearest month.

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[2] The authors are indebted to Captain Ian Benton, Chihuahua, Mexico, for the use of his data and to Dr. Morris Finkner, biometrician with the New Mexico Agricultural Experiment Station for his assistance in the statistical analysis.

[3] Department of Animal Husbandry in cooperation with the Bureau of Animal Industry, USDA, and the state experiment stations under Western Regional Project W-1 on Beef Cattle Breeding Research.

TABLE 1. MEANS, RANGES, AND STANDARD DEVIATIONS IN CALVING INTERVALS BASED ON THREE AND FIVE RECORDS PER COW, RESPECTIVELY

Group	Range	Mean	Standard Deviation
3-record	9–28 months	14.4 months	3.28 months
5-record	9–28 months	13.6 months	2.95 months

Separate analyses of variance of calving intervals were compared on two sets of data—one having three calving interval records for each cow, with a total of 537 records, and another set having five calving interval records for each cow, with a total of 390 records. Estimates of heritability were obtained by multiplying by four the paternal half-sib correlations derived from these analyses.

An intra-sire daughter-dam regression was calculated on 64 pairs of calving interval records, using first records of daughter and dam. An estimate of heritability was obtained by doubling this regression.

A random sample of calving intervals was analyzed to test the importance of the environmental components of variance. These data were composed of 162 calving interval records, with three intervals per season and with three seasons, three sequences, and six years involved in the analysis.

Results

Table 1 shows some statistics for the two groups of cows. Table 2 shows analyses of variance for calving intervals, using three and five records per cow, respectively. None of the mean square is significant.

Paternal half-sib correlations obtained from these analyses were multiplied by four, with resulting heritabilities of .008 and .012 for

TABLE 2. ANALYSES OF VARIANCE IN CALVING INTERVALS FOR THREE RECORDS AND FOR FIVE RECORDS PER COW

Source of Variation	Three Records		Five Records	
	Degrees of Freedom	Mean Square	Degrees of Freedom	Mean Square
Total	536	.....	389	....
Between cows and sires	178	11.50	77	6.62
Between sires of cows	9	13.00	7	7.85
Between cows within sires	169	11.44	70	6.50
Between intervals within cows	358	10.79	312	8.73

calving intervals based on three and five records, respectively. The intra-cow correlation of .02 calculated from the three-record data and the negative intra-cow correlation for the five-record group are indications of no repeatability.

An intra-sire daughter-dam regression was calculated on 64 daughter-dam pairs. The analysis of variance and covariance is given in table 3. The heritability estimate from this analysis is —.18.

An analysis of environmental variance of calving interval is shown in table 4. Calving interval was significantly affected by both years of calving and sequences of calving. Season of breeding and interaction mean squares were not statistically significant. Table 5 shows the means of calving sequences for these 162 records.

TABLE 3. ANALYSIS OF VARIANCE AND COVARIANCE FOR DAUGHTER-DAM PAIRS OF CALVING INTERVALS

Source of Variation	Analysis of Variance (Dams)		Analysis of Covariance
	Degrees of Freedom	Sums of Squares	Sums of Products
Total	63	746	—21
Between sires of daughters	5	69	43
Within sires of daughters	58	677	—64

Discussion

The paternal half-sib correlations obtained in this study are indicative of a very low or zero heritability for calving intervals. No doubt some cows were culled for irregular calving. If any selection of this sort occurred between different bulls' daughters, the heritabilities obtained by the half-sib correlations would be biased. This would not be true of the heritability based on the intra-sire daughter-dam regression.

The estimate of heritability from the intra-sire daughter-dam regression is in agreement with the paternal half-sib correlation estimates. The repeatability estimate indicates no permanent effect, either hereditary or environmental, with regard to permanent differences between cows.

It is possible that the elimination of certain significant environmental effects might have changed the picture with regard to the heritable portion of the total variation. However, it was not thought proper to do that, inasmuch as these environmental effects are present in

TABLE 4. ANALYSIS OF VARIANCE DUE TO ENVIRONMENTAL FACTORS ON A RANDOM SAMPLE OF CALVING INTERVALS

Source of Variation	Degrees of Freedom	Mean Squares	Percent of Total Variance
Total	161		
Between years	5	23.8**	6.7
Between sequences [1]	2	95.0**	17.5
Between seasons [2]	2	3.9	
Years x seasons	10	6.7	
Years x sequences	10	6.9	
Sequences x seasons	4	5.5	
Sequences x seasons x years	20	7.6	
Within sequences, seasons, and years	108	7.0	

** P <.01.
[1] Sequences refers to first, second, or third interval within a cow.
[2] The years were divided into three seasons of four months each.

actual practice, and it is therefore desirable to get a non-exaggerated estimate of heritability. As no other study similar to this has been reported, it is not possible to say whether these data confirm or refute other work. There are apparently many places in the reproductive process where environment or chance can affect the results. Any potential genetic effects, such as those observed by Chapman and Casida (1934, 1937) on interval from parturition to first heat and estrus cycle lengths, are cancelled by other effects. The ability to conceive and the detection of heat may be the most important factors influencing calving interval repeatability. Since heat was diagnosed without the presence of a bull, the interval could be affected by the cow's having quiet heat or being bred at the wrong time in the estrous period. Such errors would generally also occur in dairy herd studies, which constitute the bulk of the literature on the subject.

The effects of years of calving, seasons of breeding, and sequences of calving on calving interval were tested by an analysis of variance. Significant differences in calving intervals were found between years of calving and between sequences of calving. Seasons of calving, three

TABLE 5. MEANS OF CALVING INTERVALS FOR FIRST, SECOND AND THIRD CALVING SEQUENCES ON 162 RECORDS

Calving Sequence	Mean
First	15.44 months
Second	14.25 months
Third	12.88 months

first-order interactions, and one second-order interaction did not have significant mean squares.

Components of variance for the three main effects and interactions were determined, and the percent of each was calculated, with sequences contributing 17.5 percent and years 6.7 percent. Seasons and interactions contributed nothing to the total variance.

The variance contributed by sequences is probably due to the age of the cow at first calving, although many other factors could enter into sequence effect. Lasley and Bogart (1943) found that the age of a cow affects the number of services required to conceive, younger cows requiring more services. Baker and Quesenberry (1944), however, found that age was not significantly correlated with fertility. Schwarz (1953) found a heritability of 16 percent and a low repeatability of gestation length in range Angus cows.

Year contribution to the variations in the length of calving interval is also an important part of the total variation. In the area where these cows are maintained, yearly climatic fluctuations have a marked effect on forage production, and this may account for some of the variance in intervals due to years. Seasonal effects, being of short duration, apparently do not influence calving interval variation.

Summary and Conclusions

Variance in calving intervals was analyzed on data from a large Angus herd. This herd was maintained under range conditions, with year-round calving. Hand-mating was practiced. The components of genetic variance were analyzed on two sets of cows—one set of 179 cows each having three intervals and one set of 78 cows each having five intervals. Intra-sire daughter-dam regression was calculated on 64 pairs of daughter-dams observations, using the first record of the dam and the first record of the daughter.

No significant differences were found between the average performance of daughters from different sires. The heritability of calving interval was practically zero, when studied by paternal half-sib and intra-sire daughter-dam regression methods. The repeatability of calving intervals was also zero.

The components of environmental variance of calving intervals were analyzed, with three main effects—sequences, years, and seasons—and their interactions studied. Years and sequences had significant mean squares. No interactions were significant. Sequences and years contributed 17.5 percent and 6.7 percent respectively to the total variance.

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FACTORS AFFECTING THE GROWTH OF BEEF CALVES DURING THE SUCKLING PERIOD

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A USEFUL measure of a beef cow's productivity is the weight of her calf at weaning. Several investigators have reported the repeatability of weaning weight to be in the neighborhood of 50%: (Koger and Knox, 1947; Gregory *et al.*, 1950; Koch, 1951; Botkin and Whatley, 1953). A repeatability of this magnitude indicates that the weaning weight of a cow's first calf can be used profitably as a criterion in a selection program for replacement cows. Some cattlemen breed heifers as yearlings and veal the first calf at three or four months of age. Can the weight of a cow's first calf at three or four months of age be used instead of weight at the usual weaning age? The present study deals with this question by analyzing the relation between the calf's rate of growth from birth to four months and its 240 day weaning weight.

Material

The data analyzed were gathered in the University of California purebred Hereford herd located at the college farm in Davis. Monthly weights to weaning were available on 159 calves dropped during the years 1944 to 1951. Monthly weigh days were as close to the 15th of each month as possible. No attempt to get birth weights was made. A calf's first weight would be at an age somewhere between birth and one month. Subsequent weights would follow at monthly intervals. A calf was weaned on the day closest to its being eight months of age. By having monthly weights on each calf it was possible to standardize each calf's weaning weight to 240 days of age using its own successive monthly weights for a linear interpolation.

For studying a calf's early rate of growth a linear regression of the calf's weight on days of age involving the first four weights was used. On the average this covers the period from ½ to 3½ months of age. Maximum variation in the period is birth to three months as a lower limit and one month to four months as an upper limit.

The breeding herd was managed as a single unit. From about March to October it was on irrigated pastures planted to a mixture of alfalfa

[1] Davis, California.

and fescue. During this time the cows and calves received no supplements. From November to February the herd wintered in a creek bottom. The cows were fed about 20 to 25 pounds of alfalfa hay per head per day and the calves were creep fed alfalfa hay.

Analysis of Data

Prior to analyzing early rate of growth and weaning weight these traits were standardized for sex, year and season of birth, and age of dam. Correction factors for the above effects were established simultaneously through the least squares solution of the following equation:

$$(1) \quad Y_{ijklo}=\mu+a_i+b_j+c_k+d_l+m_1X_{i1klo}+m_2X^2_{i1klo}+f_1X_{i2klo}+f_2X^2_{i2klo}+e_{ijklo}$$

Where:

Y_{ijklo} = The observed trait of the Oth calf born in the ith year, of the jth sex, by the kth sire and born in the lth season.

μ = An effect common to all calves.

e_{ijklo} = An effect peculiar to the calf with observation Y_{ijklo}.

Specified effects are:

Years	a_i	$i=1, \ldots, p$	$p=7$
Sex	b_j	$j=1, q$	$q=2$
Bulls	c_k	$k=1, \ldots, r$	$r=3$
Seasons	d_l	$l=1, \ldots, s$	$s=3$

Regression on Calving sequence (For male calves) $m_1X_{i1klo}+m_2X^2_{i1klo}$

Regression on Calving sequence (For female calves) $f_1X_{i2klo}+f_2X^2_{i2klo}$

The year used in this study is from August through July. This type of year was chosen because the data involved no calves dropped in June or July and only a few in August and September. The three seasons of birth were chosen in a way considered most compatible with pasture and climatic condition. These seasons are:

Season 1: August through November 15th
Season 2: November 16 through February
Season 3: March through May

While the data were not corrected for effect of sire, sires are included in the equation in order to make the estimates of other effects more accurate. The data are from three sires. For data from other sires year and sire effect could not be disentangled.

Calving sequence (i.e., a dam's first calf, second calf, etc.) was used as an estimate of dam's age. For example, if a cow aborted her second calf or failed to be settled in her second breeding season, then her next calf was listed as calving sequence three. The heifers were first bred around 24 months of age. Calving sequence ranged from one to 12. The U.S.D.A. Bureau of Dairy Industry age correction factors for dairy cow lactations and the effect of the beef cow's age in the weaning weight of her calf reported by Knapp *et al.* (1942) suggested that a second degree regression curve might satisfactorily account for the effect of dam's age. As indicated in equation (1) second degree curves were incorporated into the model for male calves and female calves. X_{ijklo} is the calving sequence for the calf with observation Y_{ijklo}. (X values range from one to 12).

The use of the invert matrix in solving the least squares equations facilitates the estimation of standard errors and hence of confidence limits for any linear combination of effects estimated, Kempthorne (1952), Henderson (1948). Confidence limits are presented on comparisons of effects that it is felt are of general interest.

The correction factors used for standardizing early growth rate and weaning weight are presented in tables 1 and 2, respectively. Early growth rate has previously been described in detail; henceforth it will be referred to for convenience as rate of growth from birth to four months of age.

After standardizing the traits under study, they were analyzed to determine the portion of the variances and covariance due to permanent differences between cows. The analysis of variance and covariance is presented in table 3. Table 4 gives the theoretical composition of the mean squares and covariances. In table 5 are presented the estimated values of the components of variance and covariance attributed to cow differences and variation within cows.

The intra-class correlation of records by the same cow for the i^{th} trait is given by $\frac{V(Di)}{V(Ei)+V(Di)}$. This statistic is termed the repeatability of a trait, (Lush 1945); it measures the degree of similarity of repeated records by the same animal.

The following repeatability estimates were made: For rate of growth of a cow's calves from birth to four months (G) .34 with 95 percent

TABLE 1. CORRECTION FACTORS USED IN STANDARDIZING GROWTH RATE FROM BIRTH TO 4 MONTHS OF AGE

Correction for:	Class	Lb. Gained per Day to be Added	
Sex	Bull Calves	—0—	
	Heifer Calves	.13	
Age of dam in terms of calving sequence		Male Calves	Heifer Calves
	1st calves	.20	.14
	2nd calves	.13	.09
	3rd calves	.07	.05
	4th calves	.03	.02
	5th–8th calves	—0—	—0—
	9th calves	.05	.03
	10th calves	.10	.07
	11th calves	.17	.12
	12th calves	.25	.17
	Calves Born:		
Season of birth	Aug. through Nov. 15	.18	
	Nov. 16 through Feb.	—0—	
	Mar. through May	—.06	
	Calves Born:		
Year of birth	Aug. 1944–July 1945	—0—	
	Aug. 1945–July 1946	—0—	
	Aug. 1946–July 1947	—0—	
	Aug. 1947–July 1948	.05	
	Aug. 1948–July 1949	.10	
	Aug. 1949–July 1950	.12	
	Aug. 1950–July 1951	.21	

confidence limits of .51 and .16; for 240 day weaning weight (W) .48 with 95 percent confidence limits of .63 and .30.

The following correlations between traits G and W were estimated:

$$r_{GW} \text{ (Within dams)} = \frac{\text{Cov (EiEj)}}{\sqrt{[\text{V(Ei)}]\ [\text{V(Ej)}]}} = .62$$

$$r_{GW} \text{ (Between dams freed of intra-dam variation)} = \frac{\text{Cov (DiDj)}}{\sqrt{[\text{V(Di)}]\ [\text{V(Dj)}]}} = .91$$

$$r_{GW} \text{ (Between dams based on a single record)} = \frac{\text{Cov (EiEj)} + \text{Cov (DiDj)}}{\sqrt{[\text{V(Ei)} + \text{V(Di)}]\ [\text{V(Ej)} + \text{V(Dj)}]}} = .73$$

Results and Discussion

For the unadjusted data the average rate of growth from birth to four months (G) was 1.91 pounds per day with a standard deviation of .31 while for 240 day weaning weight (W) the average was 534

TABLE 2. CORRECTION FACTORS USED IN STANDARDIZING WEANING WEIGHT

Correction for:	Class	Lb. to be Added	
	Bull Calves	—0—	
Sex	Heifer Calves	68	
Age of dam in terms of calving sequence		Male Calves	Heifer Calves
	1st calves	26	18
	2nd calves	18	11
	3rd calves	11	5
	4th calves	6	0
	5th–8th calves	0	0
	9th calves	4	7
	10th calves	8	13
	11th calves	14	21
	12th calves	19	31
	Calves Born:		
Season of birth	Aug. through Nov. 15	39	
	Nov. 16 through Feb.	0	
	Mar. through May	16	
	Calves Born:		
Year of birth	Aug. 1944–July 1945	67	
	Aug. 1945–July 1946	16	
	Aug. 1946–July 1947	0	
	Aug. 1947–July 1948	71	
	Aug. 1948–July 1949	71	
	Aug. 1949–July 1950	70	
	Aug. 1950–July 1951	122	

pounds with a standard deviation of 70. The sources of variation identified in equation (1) reduced the variance of individual rates of gain 31 percent and the variance of individual weaning weights 55 percent.

Sex

It was estimated that bull calves on the average gained .13 pounds per day more than heifer calves from birth to four months of age.

TABLE 3. ANALYSIS OF VARIANCE AND COVARIANCE FOR RATE OF GROWTH FROM BIRTH TO 4 MONTHS (G) AND 240 DAY WEANING WEIGHT (W)

Source	D.F.	Mean Squares		Covariance
		G	W	GW
Between dams	56	.1050	4502	17.40
Within dams	102	.0432	1277	4.59

This difference was not statistically significant. For 240 day weaning weight bull calves were 68 pounds heavier than heifer calves. The upper and lower limits of the 95 percent confidence interval are 149 and 17 pounds. The results of previous investigators in general but not universally indicate that male calves are heavier at weaning than female calves. There has been much variation in the estimated amount. Recently, for Hereford range cattle Koch (1951) reports a 44 pound advantage for bull calves. The calves in Koch's study were weaned at about six months of age and averaged 393 pounds. The calves in this study were weaned at about eight months of age and averaged 534 pounds (unadjusted data). This age and size difference along with, and possibly in part a consequence of, the advantages of farm over range conditions in growing a calf out to weaning may account in part for the difference in these two estimates.

Age of Dam

The correction factors listed in tables 1 and 2 for the effect of age of dam on growth rate to four months of age and the 240 day weaning weight of male and female calves were obtained by comparing the ordinates of the second degree regression curves of the trait in question with respect to calving sequence as the independent variable. As previously stated the necessary regression coefficients for these curves are

TABLE 4. THEORETICAL COMPOSITION OF MEANS SQUARES AND COVARIANCE

Source	D.F.	Mean Square	Covariance
Between dams	n-1	$V(Ei)+k_o V(Di)$	$COV(EiEj)+k_o COV(DiDj)$
Within dams	$n(k_i-1)$	$V(Ei)$	$Cov(EiEj)$

$k_o=\frac{1}{n-1}\frac{(Sk_i-\frac{Sk_i^2}{Sk_i})}{Sk_i}=2.77.$

$V(Ei)$=Variance of the i^{th} trait within dams.
$V(Di)$=Variance of the i^{th} trait due to dam differences.
$COV(EiEj)$=Covariance of the i^{th} and j^{th} traits within dams.
$COV(DiDj)$=Covariance of the i^{th} and j^{th} traits due to dam differences.

TABLE 5. COMPONENTS OF VARIANCE AND COVARIANCE ATTRIBUTED TO DIFFERENCES BETWEEN DAMS AND VARIATION WITHIN DAMS

Trait	V(Ei)	V(Di)	Cov(EiEj)	COV(DiDj)
Rate of growth from birth to 4 months (G)	.0432	.0223	4.59	4.63
240 day weaning weight (W)	1277	1164		

a part of the model described in equation (1). These results indicate that young cows and old cows produce calves that grow more slowly to four months of age and are lighter in weight at weaning than the calves produced by cows of intermediate ages. These results are in general agreement with the finding of Knapp *et al.* (1942) for Hereford range cows and with the U.S.D.A. Bureau of Dairy Industry age correction factors for dairy cow lactation records. The estimated effect of age of dam on size of calf is in general smaller for female calves than for male calves. However, these data do not suggest a statistically significant difference. No exact test of significance was made but great overlaps of confidence intervals for the various age correction factors shown for the two sexes suggest a lack of significance.

In this study age of dam is expressed in terms of calving sequence. To facilitate comparison of these results with others reported in the literature in which chronological age of cow is used the summary in table 6 expresses the pertinent comparisons in terms of approximate chronological age of cow. The conversion in the cow age scale is based on an addition of two to each calving sequence number since the nearest average age in years for heifers at first calving (calving sequence 1) was three.

TABLE 6. THE EFFECT OF AGE OF COW ON THE DAILY RATE OF GROWTH FROM BIRTH TO 4 MONTHS (G), ON THE 240 DAY WEANING WEIGHT (W) AND ON 120 DAY WEIGHT (W') OF CALVES

On the Average, Calves from Cows 7 to 10 Years of Age Exceed Calves from Cows:	G (lb. Gain/Day)	W (lb.)	W' (lb.)
3 years of age by	.17	21	24
4 years of age by	.10	13	14
12 to 14 years of age by	.15	18	..

Knapp *et al.* (1942) found the optimum age range for cow productivity to be five to seven years. In this study the optimum range is from six or seven to ten years. This difference may indicate that under the more rigorous conditions of the range as compared to the farm, environmental stresses begin to limit the productivity of a cow at an earlier age.

An estimate of the effect of age of dam on the 120 day weight of calves (table 6) was made by multiplying the difference in growth rate (G) by 120 and adding a correction factor for effect of age of dam on birth weight. Since birth weights were not available in these data the following correction factors estimated by Botkin and Whatley (1953) were used. The birth weights of calves from three and four year old cows averaged four and two pounds less respectively than the birth weights of calves from cows five years and older.

Comparing W and W′ in table 6 and taking these estimates at their face value it follows that during the period from four months to eight months of age calves from first calf heifers and to a lesser extent calves from second calf cows are growing slightly faster on the average than are those from cows in the optimum age range. This result is supported by evidence from studies of the effect of a dairy cow's age on the persistency of lactation. Johansson and Hansson (1941) have shown that the persistency of yield decreases with increasing age of the cow. In their paper it is reported in graphical form that from about the eighth month of lactation on the first calf heifer is actually producing more milk than the older cows. They refer to several other investigators who have found similar results.

Repeatability of Records

The estimated repeatability of weaning weight (W), .48, is in agreement with other estimates in the literature cited in the introduction. The estimated repeatability of rate of growth from birth to four months (G) of .34 when contrasted with the larger estimate for 240 day weaning weight suggests that there has not been a diminishing maternal effect during the latter half of the suckling period. This conclusion is further supported by the estimated correlation of .91 between the true G and W values of dams. By "true" is meant the differences between dams freed of the effect of intra dam variation.

Gifford (1949) found correlations of .60, .71, .52, and .35 between daily milk production of 57 Hereford cows and daily gain in weight of

their calves during the 1st, 2nd, 3rd, and 4th months respectively. After the 4th month there was no significant relationship between the two items. He concluded that the importance of high milk production in beef cows has been over estimated.

The repeatability estimates in the present study along with the indicated greater persistency of lactation of young cows (compared with mature cows) as shown by the somewhat greater growth rate of their calves during the latter half of the suckling period suggest that the milk production of the beef cow is or can be an important factor in maternal effect during the entire suckling period.

The Growth Rate from Birth to Four Months of a Cow's First Calf as an Indicator of the Cow's Future Production

Some cattlemen that breed heifers at about 12 months of age veal the calf at three or four months of age. They feel that the drain of further lactation on the energy of the young growing cow may cause a deleterious aftermath. A question of practical interest is: Can the weight of a cow's first calf at three or four months of age serve as a basis for selecting replacement cows? The following results deal with this question. Involved in this study were data from 25 cows with three or more calves. A correlation $r_{GW}=.48$ was found between the rate of growth from birth to four months of a cow's first calf and the average 240 day weaning weight of her second and third calves (the data were standardized for environmental, sex, and age effects as previously mentioned). Squaring the correlation gives .23. Hence, according to this estimate, 23 percent of the variance of the average weaning weights of cows' second and third calves is explained by differences in the rate of growth from birth to four months of their first calves. On the basis of the G values of the first calves the five cows with the lowest records were considered culled and the remaining 20 cows as selected for herd replacements. The selected cows' second and third calves averaged 23 pounds heavier at 240 day weaning than those of the culled cows. If the n^{th} percentile (Pn) is defined as the value below which n percent of the values of a distribution lie, then the culled cows had the following percentile values in terms of the distribution of the weaning weights of the calves of the selected cows: P_{70}, P_{55}, P_{35}, P_o, P_o. According to these results some culling of first calf heifers on the basis of a partial suckling period can be done profitably.

Summary

A study has been made of the relation between the calf's rate of growth from birth to four months of age (designated as G) and its 240 day weaning weight (designated as W).

The data analyzed were eight monthly weights of each of 159 purebred Hereford bull and heifer calves out of 57 cows in the University of California herd at Davis.

Correction factors were estimated for the effects of sex, age of dam, and year and season of birth on G and W. A second degree regression curve describes adequately the effect of age of dam on both G and W. Dams in the age range seven to ten years produced the calves that grew fastest to four months of age and were heaviest at weaning (240 days). However, from four months to eight months of age the calves from first calf heifers and to a lesser extent from second calf cows grew faster than those from cows in the optimum age range. This is probably due to a greater persistency in lactation of young cows as compared to older cows since several investigators have found this to be the case in dairy cattle.

Heifer calves weighed 68 pounds less than bull calves at weaning. Differences between cows accounted for 34 percent and 48 percent of the variances of G and W respectively. The following correlations between G and W were found:

r_{GW} (within dams)$=.62$; r_{GW} (between dams)$=.91$; r_{GW} (between dams based on a single record)$=.73$.

In the light of the above estimates and the analysis of the effect of the age of dam on lactation it is concluded that the lactating ability of a cow makes a major contribution to the growth of the calf throughout the entire suckling period.

The results of a selection experiment are reported in which cows were considered culled on the basis of the G values of first calves. The results indicated that this criterion could be used to predict a cow's future production sufficiently well to warrant its use as part of a system for selecting replacement cows in the case of those cattlemen that veal a heifer's first calf at four months of age.

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NEWS AND NOTES

The forty-sixth annual meeting of the American Society of Animal Production will be held in the Hotel Sherman in Chicago, Illinois on November 26 and 27, 1954, with a dinner for the honored guest on November 28. Members planning to present papers are reminded that titles must be in the hands of the secretary, W. M. Beeson, Department of Animal Husbandry, Purdue University, Lafayette, Indiana, by July 20, following which abstracts must be filed with him by August 15.

Nominations for the Morrison Award, in writing, are due in the Secretary's Office by June 15. All members of the Society except members of the Executive Committee and the Award Committee are eligible to make one nomination. The rules governing this award were amended in 1952 and are as stated in the JOURNAL OF ANIMAL SCIENCE, Vol. 11, No. 4, pp. 807–809. All nominations must be accompanied by a brief biography of the nominee and a list, together with copies, of publications concerning the research, and a statement of the importance to the livestock industry of the work upon which the nomination is based. The cash award for 1954 will be $1,250.

Nominations for the American Feed Manufacturers Award should be sent to the Secretary's Office by June 15. Research published in 1952 and 1953 will be considered for the 1954 award. The rules governing this award are unchanged from last year and are stated in the JOURNAL OF ANIMAL SCIENCE, Vol. 7, No. 2, pp. 257–258, 1948. No formal nominations from the membership are required, although the Award Committee would appreciate receiving nominations.

L. A. Weaver, chairman of the Department of Animal Husbandry, University of Missouri, Columbia, Missouri, has been chosen as the honor guest for the American Society of Animal Production at its meeting November 26 and 27. His portrait will be presented to the Saddle and Sirloin Club at the time of the banquet in his honor on November 28. A. J. Dyer is chairman of the committee in charge of arrangements for the event.

The Western Section of the American Society of Animal Production will hold its 1954 convention on the campus of Oregon State College, Corvallis, from Sunday evening, July 11 through Wednesday noon, July 14, 1954. This meeting will be joint with the Western Division of the American Dairy Science Association.

Aldon H. Jensen, former member of the animal husbandry staff at Iowa State College, has been named assistant professor of animal science at the University of Illinois.

Leslie E. Johnson, Regional Coordinator for the North Central Regional Beef Cattle Breeding Project since 1949, will become Professor and Head of the Animal Husbandry Department at Iowa State College on July 1. He will be responsible for the teaching, research and extension programs in the fields of animal and dairy husbandry.

T. S. Hamilton, professor of animal nutrition at the University of Illinois, will become associate director of the Illinois Agricultural Experiment Station on

September 1, 1954, succeeding L. B. Howard, who will become Director of the Experiment Station.

Ralph Durham, who was formerly at the New Mexico A & M College, has joined the staff of the Animal and Poultry Husbandry Research Branch, U. S. Department of Agriculture, Beltsville, Maryland. He will be concerned with the development and evaluation of breeding methods for the identification of meat-type hogs in cooperation with state agricultural experiment stations and the extension service.

George M. Sidwell, animal husbandman at the Southwestern Range and Sheep Breeding Laboratory, Fort Wingate, New Mexico, is now stationed at the New Mexico A & M College and will work in cooperation with the experiment station.

Sex Determination by F. A. E. Crew, 3rd edition, revised in 1954, has been published by John Wiley & Sons, Inc., New York. This book deals with the cytological and genetical aspects of sex-determination.

S. H. Work, FAO Agricultural Adviser stationed in the North American Regional Office, Washington, D. C., spent the early part of December 1953 at FAO Headquarters in Rome and participated in the planning of various activities to be undertaken in the North American and Latin American Regions during 1954.

Daniel W. Beardsley has been appointed assistant animal husbandman at the Everglades Experiment Station, Belle Glade, Florida.

Max Kleiber, professor of animal husbandry at the University of California is on sabbatical leave until September 1, 1954, during which time he plans to visit Germany, Switzerland and the Scandinavian countries.

Tissue Culture by E. N. Willmer was published in February, 1954 by John Wiley & Sons, Inc., New York. This is the 2nd revised edition and treats the subject from the angle of general physiology. It deals with new methods that have produced or are likely to produce significant advances.

James F. Wilson, professor of animal husbandry at the University of California is on sabbatical leave until September 1, 1954, during which time he plans to visit Germany, Switzerland and the Scandinavian countries.

C. C. Brooks has been appointed associate professor and associate animal husbandman at the Virginia Polytechnic Institute, Blacksburg, Virginia. He will be in charge of the swine research program.

Clyde E. Smith and K. G. Jackson are new members of the Animal Husbandry Department at the University of Tennessee.

John W. A. Brant, Agricultural Officer of the Food and Agriculture Organization of the United Nations, has completed a one year assignment in Ceylon under the Expanded Technical Assistance Program, as an adviser to the Government on problems of animal nutrition, genetics and physiology. Prior to this assignment he served on the staff of the Department of Animal Science of the University of Illinois.

Martin J. Burris is now assistant professor and assistant animal husbandman at the University of Arkansas. He received his Doctorate in Animal Physiology at Oregon State College in 1953.

Charles F. Hall is assistant professor of animal husbandry and assistant veterinarian at the Arkansas Agricultural Experiment Station. He was formerly laboratory technician at the State Sanatorium, Norton, Kansas.

Jesse L. Fletcher and Troy B. Patterson of the Animal Husbandry Department at Mississippi State College are now on leave for graduate study at Texas A & M College.

The 5th edition of *Animal Breeding* by L. M. Winters was published in February, 1954, by John Wiley & Sons, Inc., New York. The chapters dealing with inbreeding, crossbreeding, selection, artificial insemination, fertility, and the development of superior germ plasm have been rewritten.

Paul B. Starks has joined the agriculture staff at the University of Tennessee, Martin Branch, Martin, Tennessee, as associate professor.

F. B. Morrison, Cornell University, and Jorge de Alba, Animal Industry Department, Inter-American Institute of Agricultural Sciences, spent the months of December, 1953 and January, 1954, in Venezuela making a detailed study of the range management and animal breeding problems of that country.

Ralph H. Boulware has joined the animal husbandry staff at the Mississippi State College as assistant professor.

Thomas C. Cook, formerly superintendent of the Knoll Creek Field Station in Nevada, is now extension agent for White Pine and Eureka counties, Ely, Nevada. He was succeeded at the Knoll Creek station by Clark R. Torell, who was formerly a graduate assistant at the University of Idaho.

F. L. Kreuzberger has been appointed instructor in animal husbandry extension at the University of Pennsylvania.

Elmer W. Hartsook is now assistant professor of animal nutrition at the University of Pennsylvania.

Robert M. Ioset has joined the teaching staff as instructor in animal husbandry at the University of Tennessee. He was formerly in the animal husbandry department at the University of Minnesota.

C. C. Chamberlain has rejoined the animal husbandry staff at the University of Tennessee as associate professor, following completion of residence work for a Doctor's Degree at Iowa State College.

A group of consultants together with representatives of the European Association of Animal Production and the Agriculture Division of FAO met in Rome last November to work out plans for the publication of a glossary of terms in the field of animal husbandry under the joint sponsorship of FAO and EAAP. Present were: Dr. A. Kiener, head of the Animal Production Branch of the Division of Agriculture in the Department of Public Economy in Berne, Professor H. Loertscher of the Faculty of Agriculture of the Polytechnic School in Zurich, and Mr. H. R. Davidson of the United Kingdom, together with staff members of EAAP and FAO. The group defined the principles which will govern the compilation of the glossary, and a foundation was laid for the work to be started.

In the reorganization of U.S.D.A., research and regulatory activities formerly under the Bureaus of Animal Industry and Dairy Industry have been separated

and regrouped along functional lines. Livestock research is now organized under three branches: Animal and Poultry Husbandry Research Branch, Dairy Husbandry Research Branch and Animal Disease and Parasite Research Branch. O. E. Reed, formerly Chief of the Bureau of Dairy Industry is now Director of Livestock Research, and Hugh C. McPhee is Assistant Director. Chiefs of the three branches are T. C. Byerly, Ralph E. Hodgson and B. T. Simms respectively.

The livestock regulatory work is also organized under three branches: Animal Disease Eradication Branch, R. J. Anderson, Chief; Animal Quarantine Branch, C. L. Gooding, Chief; and Meat Inspection Branch, A. R. Miller, Chief. A more detailed statement of the changes in organization and personnel will be published in a later issue of the Journal.

INFORMATION FOR CONTRIBUTORS

1. Papers may be submitted reporting work whose ultimate objective is clearly the solution of a livestock production problem and whose contents should be of interest particularly to those dealing with livestock production problems. Review papers on subjects of general interest will also be published at intervals, and will be prepared on invitation by the Editorial Board.

2. All papers will be subject to critical review by the Editorial Board, or others designated by the Editor. Papers needing revision will be returned to authors and should be revised and returned promptly. Papers not suitable for publication will be returned to authors with a statement of reasons for not accepting them.

3. Papers submitted should be based on new and adequate information. The following are guides to style and form:

   (a) Manuscripts must be typed, double-spaced, and the ribbon copy submitted.

   (b) Pages must be numbered. The lines of text must be numbered in the left margin, beginning with one at the top of each page. This does not apply to tabular material.

   (c) Tables should be as few and as simple as is feasible for presentation of the essential data.

   (d) Legend for each figure should be typed on a separate sheet. Photographs should be carefully prepared and labeled. Magnifications of photomicrographs should be indicated on legends. Charts should be prepared in India ink. Typed material on charts is not acceptable. Material that will not reproduce satisfactorily will be returned for revision. For suggestions on preparing illustrative material see the "Style Brief" published by the Wistar Institute Press, Philadelphia. If in doubt, consult the Editor before putting material in finished form.

   (e) The introduction should consist only of a paragraph indicating very briefly the nature of the question asked and the reason for asking it. Reference to relevant literature should be made later in the discussion of the results. Concise presentation of data is desired and there should be evidence of statistical examination wherever obviously useful in the interpretation. Unsupported hypotheses should be avoided. The organization of a manuscript may vary with the nature of the material, but all manuscripts should contain a clear statement of application of the results or their relation to some problem of the livestock industry. Each paper should end with a brief summary in the form of an abstract containing the most pertinent data in the briefest possible form.

   (f) Literature citations must be listed in alphabetical order and should be referred to in the text by author and date, i.e., Castle (1924), or (Castle, 1924). Citations may be referred to by number in review articles where the number of citations is too great to permit convenient use of the above form. "Literature cited" lists should be typed in a style used in a current issue of the JOURNAL.

4. Manuscripts will be edited in the order received, and accepted papers will be published as nearly in this order as feasible.

5. There will be a charge for making engravings in excess of one page per paper and of printing tables in excess of two pages per paper. The author will be asked when his manuscript is accepted to indicate the institution, agency or individual that will assume responsibility for the charges and for the reprints ordered at that time.

6. Authors will receive galley proof of articles together with a form for supplying an abstract for "Biological Abstracts". *Corrected proof and abstract should be mailed to the Editor within three days after they are received. Failure to do this may result in delay of publication until the next issue.*

7. One author of each manuscript should be a member of the Society. Papers by non-members can be published only after approval by the Executive Committee.

8. A "News and Notes" section will be published in each issue, including Society announcements, changes in positions and other items of professional interest concerning the members, and other items of interest to the membership. All such items should be sent promptly to the Editor.

9. Abstracts of papers to be presented at the annual meetings of the Society will be published in the November issue. Such abstracts must not exceed 250 words in length, should be typed (double spaced) and the ribbon copy submitted, the lines on the page should be numbered, in the left margin, from top to bottom, and must be in the hands of the Secretary of the Society by August 15, preceding the meeting. These abstracts must be summaries of results and conclusions.

10. Presentation of a paper at the annual meeting does not exclude it from publication in complete form in the JOURNAL. Such papers may be submitted to the Editor and will be given equal consideration with others submitted.

11. All manuscripts and correspondence concerning them should be addressed to the Editor: Dr. L. E. Casida, Department of Genetics, University of Wisconsin, Madison, Wisconsin, or to the publishers: Boyd Printing Company, 372–374 Broadway, Albany 7, New York.

12. All correspondence concerning subscriptions to the JOURNAL OF ANIMAL SCIENCE and other business matters should be addressed to the Business Manager, Dr. W. M. Beeson, Department of Animal Husbandry, Purdue University, Lafayette, Ind., or to the publishers, Boyd Printing Company, 372–374 Broadway, Albany 7, New York.